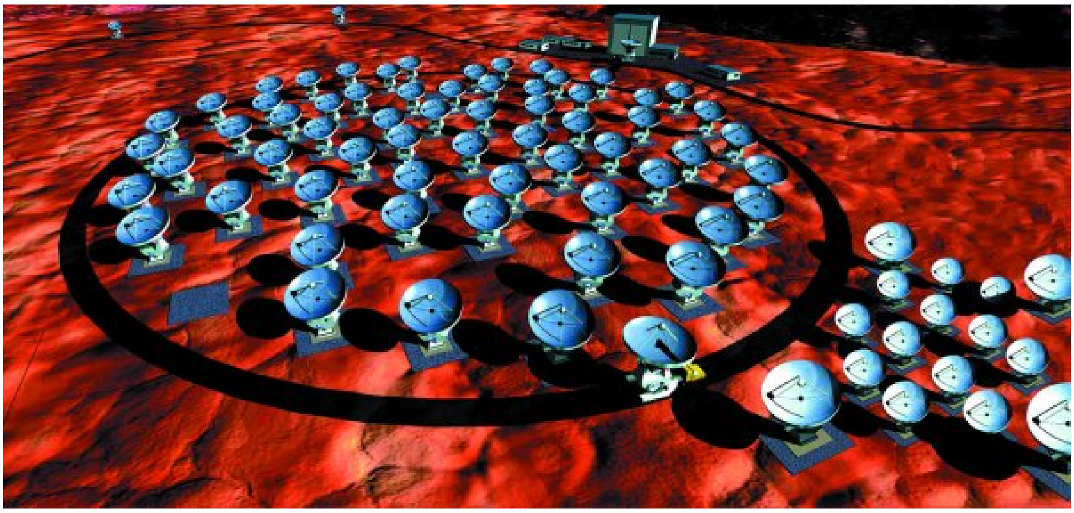
Science with ALMA: a new era for Astrophysics

International Conference

13 - 17 November 2006, Madrid, Spain



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The Organizing Committees of the Science with ALMA international conference are grateful for the interest and financial support given by the following institutions and associations:

- Consejo Superior de Investigaciones Científicas (CSIC, MEC), Spain
- Observatorio Astronómico Nacional (IGN, Ministerio de Fomento), Spain
- Atacama Large Millimeter Array (ALMA)
- European Southern Observatory (ESO)
- National Radio Astronomy Observatory (NRAO), USA
- National Astronomical Observatory of Japan (NAOJ), Japan
- RadioNet
- Astrocam, Comunidad Autónoma de Madrid, Spain

Motivation

Currently under construction in the Andean Altiplano, Northern Chile, the Atacama Large Millimeter/submillimeter Array (ALMA) is an international astronomy facility, a radio interferometer composed of at least 54 antennas of 12 m diameter, and twelve 7 m antennas with about 6 600 m^2 of total collecting area. Initially covering the most interesting spectral wavelength ranges from 3 to 0.3 mm, ALMA will be a revolutionary telescope providing astronomy with the first detailed view of the dark and youngest objects of the Universe.

ALMA is a partnership of Europe, Japan and North America in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organisation for Astronomical Research in the Southern Hemisphere, in Japan by the National Institutes of Natural Sciences (NINS) in cooperation with the Academia Sinica in Taiwan and in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC). ALMA construction and operations are led on behalf of Europe by ESO, on behalf of Japan by the National Astronomical Observatory of Japan (NAOJ) and on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI).

The scientific preparations for ALMA are being extremely active since the birth of the project. The various science committees, groups of astronomers working for ALMA, and regional communities interested in the project meet regularly to exchange ideas about the scientific capabilities and first observations to be carried out with the interferometer. A first world-wide conference on "Science with the Atacama Large Millimeter Array" took place in Washington, D.C. (USA), on 6-8 October 1999.

The conference held in Madrid (Spain), on 13-17 November 2006, is the second world-wide meeting on "Science with the Atacama Large Millimeter Array". This international ALMA conference is envisioned as a way for the astronomers interested on ALMA, not necessarily radioastronomers, to exchange views, to plan preparatory observations in view of the scientific exploitation of the interferometer, and to obtain the information needed to orient their scientific work to the best possible use of ALMA.

The conference covers a wide range of topics, which indeed includes the main scientific drivers of ALMA: the formation and evolution of galaxies, the physics and chemistry of the interstellar medium, and the processes of star and planet formation.

Registered participants

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Oral scientific program

MONDAY, NOV 13

8h00-9h00 Registration
9h00-9h30 Welcome and practical information

Section 1 : The project

Chair : Catherine Cesarsky

09h30-10h00 Massimo Tarenghi : Status of the ALMA project $\boxed{I}$
10h00-10h30 Al Wootten : The ALMA capacities for line observations $\boxed{I}$
10h30-11h00 Tom Wilson : Continuum capabilities with ALMA $\boxed{I}$

11h00-11h30 Coffee break

Chair : Fred Lo

11h30-12h00 Ryohei Kawabe : The ACA array $\boxed{I}$

Section 2 : Star Formation

12h00-12h30 Ewine van Dishoeck : ALMA and star formation: an overview $\boxed{I}$
12h30-13h00 Riccardo Cesaroni : High mass star forming regions: an ALMA View $\boxed{I}$

13h00-15h00 Lunch

Chair : Al Wootten

15h00-15h30 Philippe André : Low Mass Star forming regions $\boxed{I}$
15h30-16h00 Debra Shepherd : Molecular Outflows $\boxed{I}$
16h00-16h30 Yuri Aikawa : Chemistry in low mass star forming regions: ALMA's contribution $\boxed{I}$
16h30-17h00 Stéphane Guilloteau : A new view of Protoplanetary disks with ALMA $\boxed{I}$

17h00-17h30 Coffee Break

Chair : Satoshi Yamamoto

17h30-18h00 David J. Wilner : The ALMA view of Dust Evolution: Making Planets and Decoding Debris $\boxed{I}$
18h00-18h15 Claudia Comito : High-resolution mm interferometry and the search for massive protostellar disks: the case of Cep-A HW
18h15-18h30 Brenda Matthews : Most Recent Results of the Ongoing Study of the Class 0 Source Barnard 1c
18h30-18h45 Crystal Brogan : High Resolution SMA Observations of the Hot Core Line Emission from Massive Protostellar Objects
18h45-19h00 Friedrich Wyrowski : APEX and ATCA observations of the remarkable southern hot core G327.2-0.6 and its environs
19h00-19h15 Bérengère Parise : The physical conditions in the BHR71 outflows
19h15-19h30 Darek Lis : Interstellar Deuteroamonia : Tracing physical conditions in cold and dense ISM

TUESDAY, NOV 14

Section 2 : Star Formation (cont.)

Chair : Rafael Bachiller

09h00-09h15 Leonardo Bronfman : Massive Star Formation in the Southern Milky Way
09h15-09h30 Josep M. Girart : SMA observations of the magnetic fields around a low-mass protostellar system
09h30-09h45 Tetsuo Hasegawa : ASTE Observations of the massive star forming region SgrB2 : A Giant Impact Scenario
09h45-10h00 Michel Guélin : Unveiling the chemistry of hot protostellar cores with ALMA

Section 3 : Proto-Planets and substellar objects

Chair : Stephane Guilloteau

10h00-10h30 Nagayoshi Ohashi : Observational signatures of planet formation: The ALMA view $\boxed{I}$
10h30-11h00 Sebastian Wolf : Detecting Protoplanets with ALMA $\boxed{I}$

11h00-11h30 Coffee Break

11h30-12h00 Antonella Natta : The study of substellar objects with ALMA $\boxed{I}$
12h00-12h15 Sean Andrews : A Submillimeter View of Protoplanetary Disks

Section 4 : Molecular Clouds

Chair : Ewine van Dishoeck

12h15-12h45 Doug Johnstone : Observations of Dust in Molecular Clouds with ALMA
12h45-13h00 Asunción Fuente : High angular resolution imaging of the circumstellar material around intermediate mass stars
13h00-13h15 Izaskun Jiménez : Revealing the“fingerprints” of the magnetic precursor of C-shocks

13h15-15h00 Lunch

Chair : Tetsuo Hasegawa

15h00-15h30 Richard M. Crutcher : Polarization measurements of molecular lines with ALMA $\boxed{I}$

15h30-16h00 Mario Tafalla : Observations of Protostellar cores with ALMA $\boxed{I}$

16h00-16h30 Jesús Martín-Pintado : ALMA and the Galactic Center $\boxed{I}$

16h30-17h00 Akiko Kawamura : Molecular clouds and star formation in the Magellanic clouds and the Milky Way $\boxed{I}$

17h00-17h30 Coffee Break

Chair : Michel Guélin

17h30-18h00 John C. Pearson : Laboratory Data, Line Confusion and Other Unique Opportunities and Challenges for ALMA Line Surveys $\boxed{I}$

18h00-18h30 Eric Herbst : Chemistry in the ISM : The ALMA revolution $\boxed{I}$

18h30-18h45 Nami Sakai : Complex organic molecules in an early stage of protostellar evolution

18h45-19h00 Diego Mardones : Dense cores in the massive star forming region NGC6334

19h00-19h15 Satoko Takahashi : A new Scenario of intermediate mass star formation revealed by multi-wavelength observations of OMC-2/3

19h15-19h30 Shigehisa Takakuwa : Scientific role of the ACA in the ALMA project for the field of star formation

WEDNESDAY, NOV 15

Section 5 : Solar System

Chair : Tom Wilson

09h00-09h30 Bryan Butler : ALMA Observations of Solar System Bodies $\boxed{I}$

09h30-10h00 Emmanuel Lellouch : The study of Planetary Atmospheres with ALMA $\boxed{I}$

10h00-10h30 Dominique Bockelée-Morvan : The study of Comets with ALMA $\boxed{I}$

10h30-11h00 Amy J. Lovell : Observation of Asteroids with ALMA $\boxed{I}$

11h00-11h30 Coffee Break

11h30-11h45 Maria Loukitcheva : ALMA as the ideal probe of the solar chromosphere

11h45-12h00 Mark Hofstadter : Millimeter and Submillimeter Observations of Uranus and Neptune

Section 6 : Evolved Stars

Chair : Peter Schilke

12h00-12h30 Hans Olofsson : The study of evolved stars with ALMA $\boxed{I}$

12h30-13h00 Valentín Bujarrabal : The Molecular Content and Physical Structure of Protoplanetary Nebula $\boxed{I}$

13h00-15h00 Lunch

15h00-15h30 Patrick J. Huggins : Planetary Nebulae and ALMA $\boxed{I}$

15h30-16h00 Tom Millar : Chemistry in the ISM : Unveiling the dust formation zone $\boxed{I}$

16h00-16h15 Raghvendra Sahai : A massive bipolar outflow and a dusty torus with large grains in the PPN IRAS 22036+5306

16h15-16h30 Marcelino Agúndez : Understanding the chemical complexity of the CSE of C-rich stars : IRC+10216

16h30-16h45 Javier Alcolea : New Plateau de Bure Observations of M1-92 : unveiling the core

Section 7 : Galaxies

Chair : Christine Wilson

16h45-17h15 Linda Tacconi : An overview of Galaxy Formation with ALMA $\boxed{I}$

17h15-17h45 Coffee Break

17h45-18h15 Kazushi Sakamoto : Gas dynamics and structure of galaxies $\boxed{I}$
18h15-18h45 Min Yun : Star Formation in Galaxies $\boxed{I}$
18h45-19h15 Jean L. Turner : Chemical Complexity in Nearby galaxies $\boxed{I}$
19h00-19h15 Sergio Martín : The Galactic Center as nearby extragalactic chemical laboratory through Molecular line surveys
19h15-19h30 Santiago García-Burillo : Probing the feeding and feedback of activity in galaxies near and far.

THURSDAY , NOV 16

Section 7 : Galaxies (cont)

Chair : Linda Tacconi

09h00-09h30 Sussane Aalto : Chemistry in active Galaxies $\boxed{I}$
09h30-10h00 Kotaro Kohno : Dense gas in nearby active and normal galaxies $\boxed{I}$
10h00-10h30 Michael Regan : Star formation in galaxies: multiwavelength insights $\boxed{I}$
10h30-11h00 Nick Scoville : Spectroscopic Surveys of Cosmic Evolution $\boxed{I}$

11h00-11h30 Coffee Break

Chair : Lourdes Verdes-Montenegro

11h30-11h45 Nario Kuno : Observations of Molecular Clouds in Nearby Galaxies with ALMA
11h45-12h00 Christine Wilson : Luminous Infrared galaxies with SMA : Probing the extremes of Star Formation

Section 8 : High redshift galaxies and Cosmology

Chair : Lourdes Verdes-Montenegro

12h00-12h30 David Hughes : Large scale extragalactic continuum surveys with ALMA $\boxed{I}$
12h30-13h00 Frank Bertoldi : Continuum observations of high-z objects $\boxed{I}$

13h00-15h00 Lunch

21h00 CONFERENCE DINNER TALK: Paul Vanden Bout

FRIDAY, NOV 17

Section 8 : High redshift galaxies and Cosmology (cont.)

Chair : Félix Mirabel

10h00-10h30 Fabian Walter : Search for the most distant objects with ALMA $\boxed{I}$
10h30-11h00 Toru Yamada : Multi-wavelength observations of very distant galaxies $\boxed{I}$

11h00-11h30 Coffee Break

11h30-12h00 Dale A. Frail : ALMA and the high-z GRBs $\boxed{I}$

12h00-12h30 Yoshiaki Taniguchi : Lyman-α emitters at highest redshift. Extensive study in the field of starburst galaxies from nearby to high-z $\boxed{I}$

12h30-12h45 Chris Carilli : Observations of First Light with ALMA

12h45-13h00 Wei-Hao Wang : Is ALMA Going to See Many High-Redshift $(z > 4)$ Galaxies?

13h00-15h00 Lunch

Chair : Chris Carilli

15h00-15h30 Françoise Combes : Molecular Absorption measurements in high-z objects $\boxed{I}$

15h30-16h00 Naoshi Sugiyama : Cosmology and SZ with ALMA $\boxed{I}$

16h00-16h15 Javier Graciá-Carpio : Molecular gas in a large ULIRG sample : the low redshift connection to the huge high-z starbursts and AGNs

16h15-16h30 Serena Viti : Molecular Signatures of Star Formation at high-redshifts

Conference Summary :

16h30-17h00 A. Sargent and P. Cox : Galactic and Extragalactic/Cosmology

Abstracts of oral contributions

Status of the ALMA project *(invited)*

Massimo Tarenghi, ALMA

The Atacama Large Millimeter/submillimeter Array (ALMA) is an international radio telescope under construction in the Atacama Desert of northern Chile. ALMA will be situated on a high-altitude site at 5000m elevation which provides excellent atmospheric transmission over the instrument wavelength range of 0.3 to 3 mm. ALMA will be comprised of two key observing components –an array of up to sixty-four 12m diameter antennas arranged in multiple configurations ranging in size from 0.15 to 14 km, and a set of four 12m and twelve 7m antennas operating in closely packed configurations (known as the Atacama Compact Array, or ACA), providing both interferometric and total-power astronomical information. High-sensitivity dual-polarization 8 GHz bandwidth spectral line and continuum measurements between all antennas will be available. At the shortest planned wavelength and largest configuration, the angular resolution of ALMA will be 0.005″. The instrument will use superconducting (SIS) mixers to provide the lowest possible receiver noise contribution, and a water vapor radiometers to assist in calibration of atmospheric phase distortions. A complex optical fiber network will transmit the digitized astronomical signals from the antennas to the correlators in the Array Operations Site Technical Building, and post-correlation to the lower-altitude Operations Support Facility data archive. Array control, and initial construction and maintenance of the instrument, will also take place at the OSF. ALMA Regional Centers in the US, Europe and Japan will provide the scientific portals for the use of ALMA; a call for early science observations is expected in 2009. In this paper, we present the status of the ALMA project as of today.

The ALMA capacities for line observations *(invited)*

Al Wootten, JAO & NRAO

ALMA's large collecting area and location on a high dry site provide it with unparalleled potential for sensitive spectral line observations. Its wide frequency coverage, superb receivers and flexible backend will ensure that potential is met. Since the last meeting on ALMA Science, the ALMA team has substantially enhanced its capability for line observations. ALMA's sensitivity has increased with the addition of the 16 antennas of the ACA, equivalent to eight additional 12m telescopes. The first four cartridges for the baseline ALMA have been accepted, with performance above the already-challenging specifications. ALMA's flexibility has increased with the enhancement of the baseline correlator with tunable filter banks, and with the addition of a separate correlator for the ACA. As an example of the increased flexibility, ALMA is now capable of multi-spectral-region and multi-resolution modes. With the former, one might observe e.g. four separate transitions anywhere within a 2 GHz band with a high resolution bandwidth. With the latter, one might simultaneously observe with low spectral resolution over a wide bandwidth and with high spectral resolution over a narrow bandwidth; this mode could be useful for observations of pressure-broadened lines with narrow cores, for example. Several science examples will be presented illustrating ALMA's potential for transforming millimeter and submillimeter astronomy.

Continuum Capabilities with ALMA *(invited)*

T.L. Wilson, ESO

The extremely dry site, the very sensitive receivers with wide band widths, the more than 6000 m^2 of collecting area, the high dynamic range and the high surface accuracies of the antennas all lead to an extraordinary sensitivity of ALMA at frequencies to ν=900 GHz. The flux densities of thermal emitters are small at 100 GHz but increase rapidly with frequency, so ALMA will have a unique capability to detect, image and determine continuum spectral indicies for a wide range of objects. Except for black body emission from planets, in the meter and centimeter wavelength range emission is dominated by the synchrotron or free-free emission. In the millimeter, sub-mm and far infrared range, broadband continuum emission from interstellar sources is caused by radiation from dust particles. The flux densities show spectral indicies of $\nu^{2+\beta}$, where β is in the range 1 to 2. This is very different from synchrotron radiation, so the mechanisms can be separated. For a given dust to gas ratio, the continuum intensity from dust is proportional to the product of T_{mD} and N(H), where N(H) is the column density of protons and T_{mD} the dust temperature. A few examples are high redshift sources, galaxies, molecular clouds, planets (normal or dwarf) or asteroids. Because of the inverse k correction, ALMA can detect active star forming galaxies such as M82 even at redshifts of z=12. In addition to the examples mentioned above, another first priority science goal of ALMA is measurements of the Sun. In addition to the solar system, the photospheres of O and B stars will be detectable.

The ACA array *(invited)*

Ryohei Kawabe, ALMA-J Office NAOJ, Japan

The ACA system is one of Japanese contribution to the enhanced Atacama Large millimeter/Sub-millimeter Array (ALMA) that is tri-partite project by Europe, Japan, and North America (NA). The role of the ACA system is to provide short baseline data and total power data with high precision in order to complement the 12m Array data and to enhance the image fidelity particularly for extended astronomical sources. The short baseline data are provided with the 7m array configured compact. The TP array also enhances sensitivity for the calibration of the ACA 7-m array. In addition to the coordinated observations to complement the 12m Array, stand-alone observations will be performed by ACA. The scientific importance and science operations plan of the ACA system are reported.

ALMA and star formation: an overview *(invited)*

Ewine F. van Dishoeck, Leiden Observatory, Leiden University

An overview will be presented of the exciting science enabled by ALMA in the field of star formation. In cold pre-stellar cores, ALMA will be able to image the collapse of the central regions where most molecules are frozen out onto grains. In nearby low-mass YSOs, ALMA will offer spatial resolutions down to a few AU and can disentangle the complex physical structure of infalling, outflowing and rotating material. ALMA will be able to probe the formation and evolution of disks in the embedded stages and separate it from the envelope. Through red-shifted absorption against the continuum, the accretion rate of matter onto deeply embedded protostars can be measured. In high-mass regions, ALMA will be able to test competing formation scenarios through the collapse and fragmentation of a single massive cloud clump versus the merging of low-mass stars in the center of a cluster. Comparison between high-resolution ALMA and radio images can reveal the progression of star formation within a cloud and test theories of triggered star formation. The resolution of ALMA is also essential to trace the outflows back to their sources, and disentangle the complex web of motions. Finally, in both low- and high-mass regions, ALMA will be able to detect and image a myriad of simple and complex organic molecules and determine quantitatively the chemical composition of the gas available for planet formation. The importance of Spitzer data in providing unbiased samples of sources for ALMA will be emphasized. Examples of recent (sub)millimeter data will be presented and the synergy with other facilities will be mentioned.

High mass star forming regions: an ALMA View *(invited)*

Riccardo Cesaroni, INAF - Oss. di Arcetri

High-mass stars form deeply embedded in their parental cores, still undergoing significant mass accretion. Although radiation pressure is expected to halt and even reverse such accretion, as a matter of fact stellar masses up to many 10 $M_\odot$ are assembled. While theorists have proposed various solutions for the radiation pressure problem, observers have been hindered by the limited angular resolution and sensitivity of currently available instruments. In particular, it would be crucial to investigate the circumstellar region where infall and/or disk formation is expected to occur. This result will be achievable with ALMA. After a brief description of the radiation pressure problem and proposed solutions, I will illustrate recent findings from interferometric multi-wavelength observations which constitute an excellent starting point for future ALMA observations. The high densities and temperatures present in OB star forming regions make these an ideal benchmark to test the most extreme capabilities of the instrument. With this in mind, examples will be given of possible applications of ALMA with reference to specific cases.

Low Mass Star Forming Regions *(invited)*

Philippe André, CEA Saclay

The study of the earliest stages of star formation in molecular clouds is one of the fields that should benefit most from ALMA. Improving our understanding of these deeply embedded stages is crucial to gain insight into the origin of stellar masses and binary systems. While the use of large single-dish (sub)millimeter radiotelescopes and existing interferometers has led to good progress on the overall density structure of isolated prestellar cores and young protostars, many questions remain open concerning, e.g., their fragmentation properties and detailed kinematics. Furthermore, the classical paradigm for the formation of single low-mass stars in well-separated, magnetized prestellar cores has been challenged on the grounds that most young stars actually belong to multiple systems and/or coherent clusters. A new paradigm based on supersonic turbulence has emerged which emphasizes the role of dynamical interactions between individual (proto)stars in cluster-forming clumps. The debate is far from settled, however, and ALMA will greatly help to discriminate between these two paradigms. In particular, I will discuss the unique potential of ALMA for constraining the formation process of binary (proto)stars and identifying proto-brown dwarfs, hence for shedding light on the origin of the low-mass end of the stellar initial mass function.

Molecular Outflows *(invited)*

Debra Shepherd, National Radio Astronomy Observatory

Optical, infrared and radio (single dish and interferometric) observations of jets and outflows from newly formed stars have helped to improve our understanding of molecular outflows and the outflow/accretion connection. However, once the Atacama Large Millimeter Array (ALMA) is completed, it will provide a significant increase in sensitivity and resolution at millimeter and sub-millimeter wavelengths that will allow astronomers to address critical issues that cannot be explored with established observatories. Of particular importance is that ALMA will recover both extended and compact emission (from the large scale molecular cloud and outflows to compact cores and disks). Thus, we will be able to study the detailed kinematics of the outflows, entrainment properties, momentum transfer and feedback, and collimation. I will review our current observational limitations and provide examples of how ALMA will contribute to the study of molecular outflows in star forming regions and compliment other new or expanded observatories.

Chemistry in low-mass star forming regions: ALMA's contribution *(invited)*

Yuri Aikawa, Kobe University,
Valentine Wakelam, The Ohio State Univ., Robin T. Garrod, The Ohio State Univ., Eric Herbst, The Ohio State Univ., Hiroshi Koyama, Kobe University, Paola Caselli, Center for Astrophysics

Stars are formed by contraction of molecular cloud cores. Since the kinetics of cores is probed by molecular lines, chemistry is important in deriving the star-formation processes from the observational data. Recent observations have shown that the molecular abundances in cores vary spatially and temporally, which indicates that chemistry can be a powerful tool to investigate the evolutionary stage of the cores. In the central regions of cold prestellar cores, CO is frozen onto grains. On the other hand, N-bearing species are not depleted. Our model shows that the survival of N-bearing species is caused by the depletion of CO and slow formation of N_2 in the gas phase. Depletion of CO also enhances the molecular D/H ratio. As the contraction proceeds, compressional heating overwhelms the radiative cooling. CO is sublimated back to the gas phase if the temperature reaches 20 K. Warm temperature enhances the endothermic reactions (ex. H_2D^+ + H_2 -> H_3^+ + HD), which were negligible in the prestellar core stage, and also enhances grain-surface reactions among heavy-element species to form complex molecules. If the temperature reaches $\sim$ 100 K, less volatile species, such as methanol, are sublimated. Such warm regions with large organic gaseous molecules are called hot corinos or low-mass hot cores. According to a theoretical model, for example, CO is sublimated to the gas-phase inside the radius of 100 AU, and the hot-core like region extends to the radius of 10 AU at the moment of the birth of a protostar. I will present a model that follows the chemistry from the prestellar phase through to the protostellar phase, and discuss what we can observe with ALMA.

A new view of Protoplanetary disks with ALMA *(invited)*

Sthéphane Guilloteau, Observatoire de Bordeaux

The dynamical, physical and chemical processes which lead to planet formation is an astrophysical domain which will strongly benefit from ALMA in term of frequency coverage, sensitivity and angular resolution. In this review, recent results from current mm/submm interferometers obtained on molecules and dust in proto-planetary disks are presented. The observational coupling between gas and dust is discussed and it is shown that dust disks must be analysed with the knowledge provided by gas disks, and respectively, both from the chemical and physical points. For these purposes, the methods of analysis of mm/submm interferometric data specific to disks are summarized. Emphasis is given on recent, unexpected, findings obtained in the highest sensitivity and resolution observations obtained so far, as they provide a hint of what ALMA could discover. A comparison with the expected sensitivities for ALMA illustrates how ALMA can enhance our knowledge of the disk physics, either by providing statistics or by allowing much more detailed studies of representative objects.

The ALMA view of Dust Evolution: Making Planets and Decoding Debris *(invited)*

David Wilner, Harvard-Smithsonian Center for Astrophysics

Dust particles in disks around young stars collide and grow from sub-micron sizes to pebbles, boulders, planetesimals, and eventually to planets. I will discuss several ways that ALMA will provide unprecedented views of this process through high resolution observations of thermal dust emission. ALMA will test disk evolution models that predict coagulation and sedimentation through precision imaging of spectral index variations indicative of the grain size distributions. ALMA will pinpoint when and where giant planets form by imaging the AU scale gaps they open in disks. ALMA observations also promise new insights into mature planetary systems, where the collisions of remnant planetesimals replenish the circumstellar environment with tenuous dusty debris. The periodic perturbations of planets, if present, can sculpt this second generation dust into regular patterns of high contrast at millimeter wavelengths. Detailed images of debris disks can be compared to numerical simulations of orbital dynamics to decode the properties of perturbing planets. The high sensitivity and high resolution of ALMA will allow detection of orbital motions over time. Moreover, localizing the dust producing planetesimals can reveal important aspects of dynamical evolution, much like resonant Kuiper Belt populations in our Solar System today reveal the migration history of Neptune.

High-resolution mm interferometry and the search for massive protostellar disks: the case of Cep-A HW2

Claudia Comito, MPIfR Bonn,
Peter Schilke, MPIfR Bonn, Ulrike endesfelder, MPIfr Bonn, Izaskun Jiménez-Serra, IEM/CSIC Madrid, Jesús Martín-Pintado, IEM/CSIC Madrid

The direct detection of accretion onto massive protostars through rotating disks constitutes an important tile in the massive-star-formation-theory mosaic. This task is however, from the observational point of view, very difficult to pursue, because of the large distances involved and of the complexity of such regions. A very interesting example is Cepheus A East: one of the closest known regions of massive star formation, this object displays a large-scale outflow, which has been observed by many authors in a variety of molecular tracers, and which seems to originate close to the radio-continuum source HW2. The properties of the molecular emission around HW2 seems to suggest the presence of a massive rotating disk (cf. Patel et al. 2005). We have carried out sub-arcsec-resolution PdBI observations of high-density and shock tracers such as SO_2, SiO, CH_3CN, and CH_3OH towards the center of the outflow. This experiment shows very clearly that the dense gas around HW2 is distributed perpendicularly to the axis of the flow. Moreover, some of the above-mentioned species, particularly SO_2 and CH_3CN, even show a velocity gradient along the major axis of the elongated structure, which at first glance seems compatible with the presence of a rotating accretion disk. *However*, a detailed analysis of the spatial distribution and of the velocity field traced by **all** observed species leads us to conclude that the Cep-A "disk" is actually the result of the superposition of multiple molecular outflows with at least one hot-core-type object.

Most Recent Results of the Ongoing Study of the Class 0 Source Barnard 1c

Brenda Matthews, Herzberg Institute of Astrophysics,
Antonio Crapsi, Leiden Observatory, Michiel Hogerheijde, Leiden Observatory, Jes Jørgensen, Harvard-Smithsonian Center for Astrophysics, Ted Bergin, University of Michigan

We present our most recent results of an in-depth study toward the Class 0 source Barnard 1c in Perseus. This source is of particular interest because it exhibits evidence of strong alignment of grains all the way to the core centre, which is contrary to all other low mass protostellar cores. We hope to clarify the source of poor alignment in other sources by identifying the source of strong aligment in B1c. A central cavity has been identified in N_2H^+ emission, suggesting heating in the centre has released CO, destroying N_2H^+. High resolution polarimetry data are expected in Sept 2006. We will present the results of these observations as well as our most recent models for the central structure and molecular abundances toward this core.

High Resolution SMA Observations of the Hot Core Line Emission from Massive Protostellar Objects

Crystal Brogan, National Radio Astronomy Observatory,
Todd Hunter, National Radio Astronomy Observatory, Remy Indebetouw, University of Virginia

I will present results from recent high resolution ($< 1''$) SMA 345 GHz observations of four massive protostellar objects with copious hot core emission. At the distances of the four sources: NGC6334I, G5.89-0.39, W33A, and AFGL2136, the linear resolution is better than 4000 AU. We will compare and contrast the properties of (1) spatial chemical differentiation; (2) chemical abundance; and (3) kinematic behavior of different species between the four sources.

APEX and ATCA observations of the remarkable southern hot core G327.3-0.6 and its environs

Friedrich Wyrowski, MPIfR ,
Karl Menten, MPIfR, Peter Schilke, MPIfR, Sven Thorwirth, MPIfR, Per Bergman, OSO/ESO

There is no generally accepted evolutionary scheme for high mass star formation yet. A simple approach to address this problem is to cover several of the known stages during the formation of massive stars in the same cloud and then investigate their properites. Here we present such a project conducted with complementary APEX and ATCA observations. These observations show a compact and bright single hot core in the G327.3-0.6 region on a 0.03 pc scale with a mass of 500 $M_\odot$ and 0.5-1.5 10^5 $L_\odot$. Additionally a clumpy filament is seen in N_2H^+. Together with cm continuum observations, the data reveal like pearls on a string several stages of massive star formation, with likely the youngest stages hiding in the cold N_2H^+ cores analysed with a multilevel study of the APEX and ATCA observations.

The physical conditions in the BHR71 outflows

Bérengère Parise, Max Planck für Radioastronomie,
Arnaud Belloche, Max Planck für Radioastronomie, Silvia Leurini, Max Planck für Radioastronomie, Peter Schilke, Max Planck für Radioastronomie

Highly-collimated outflows are believed to be the earliest stage in outflow evolution, so their study is essential for understanding the processes driving outflows. The BHR71 Bok globule is known to harbour such a highly-collimated outflow, which is powered by a protostar belonging to a protobinary system. Using the APEX telescope on Chajnantor, we mapped the BHR71 highly-collimated outflow in CO(3-2), and observed several bright points of the outflow in the molecular transitions CO(4-3), ^{13}CO(3-2), C^{18}O(3-2), CH_3OH(7-6) and H_2CO(4-3). We use an LVG code to characterise the temperature enhancements in these regions. These observations are particularly interesting for investigating the interaction of collimated outflows with the ambient molecular cloud. In our CO(3-2) map, the second outflow driven by IRS2, which is the second source of the binary system, is completely revealed and shown to be bipolar. We also measure temperature enhancements in the lobes. The CO and methanol LVG modelling points to temperatures between 30 and 50K in the IRS1 outflow, while the IRS2 outflow seems to be warmer (up to 300K).

Interstellar Deuteroammonia: Tracing Physical Conditions in Cold, Dense ISM

D.C. Lis, Caltech,
M. Gerin, Observatoire de Paris, E. Roueff, Observatoire de Paris, T.G. Phillips, Caltech

In recent years, the chemistry of dense cores has been revisited with the discovery of a plethora of multiply deuterated molecules and of large depletions of CO. The two processes are closely related, since the condensation of CO and other abundant species onto dust grains enhances deuterium fractionation in the gas phase by decreasing the destruction rate of H_3^+ and its deuterated variants. Condensation of some stable species onto dust grains leads to systematic molecular differentiation, as is now firmly established in starless cores. The strong drop in abundance of CO and CS is naturally explained by depletion onto dust grains at densities above a few times 10^4 cm^{-3}. N_2H^+ seems unaffected by this process up to densities of order a few times 10^5–10^6 cm^{-3}, while the NH_3 abundance may actually be enhanced in central regions of starless cores. Recent chemical calculations suggest that at densities in excess of 10^6 cm^{-3}, even the N-bearing species should eventually disappear from the gas phase. Under such "complete freezeout" conditions, H_3+ and its deuterated isotopologues become the best tracers of the molecular gas. As the density threshold for the complete freezout is time and model dependent, good observational constraints are needed. Our recent observations of the ground state submillimeter lines of deuterammonia suggest that this molecule is not completely frozen out in the high-density gas. In particular the submillimeter lines of ND_2H are relatively strong, have moderate opacities and simple hyperfine patterns that allow accurate determination of the excitation temperature, H_2 volume density, and molecular column density. Observations of these lines thus provide new opportunities to study the physics and chemistry of cold, dense ISM, where most molecules are depleted onto dust grains. Planned absorption studies with the HIFI instrument on Herschel will also provide insights into the physics and chemistry of diffuse clouds along the lines of sight toward bright submillimeter continuum sources, where many complex molecules have already been detected.

Massive star forming regions in the southern Milky Way

Leonardo Bronfman, Universidad de Chile

A large molecular line data base of massive star forming regions in the southern Milky Way, compiled during the past decade, will be presented. The confinement of these regions into giant molecular clouds, their large scale radial distribution, and the spiral arm segments they trace, will be displayed. Some of the foremost regions, candidates for future ALMA observations, will be described in more detail, using millimeter continuum and line emission maps obtained with the SEST, APEX, and ASTE telescopes. These regions range from massive cold cores to molecular outflows, and include some multiple systems evolving along a complete GMC.

SMA observations of the magnetic fields around a low-mass protostellar system

Josep Miquel Girart, Institut de Ciències de l'Espai (CSIC-IEEC),
Ramprasad Rao (SMA-ASIAA), Daniel P. Marrone (CfA)

We present high angular resolution 345 GHz observations of polarized dust emission towards the low-mass protostellar system NGC 1333 IRAS 4A. We show that in this system the observed magnetic field morphology is in agreement with the standard theoretical models of formation of low-mass stars in magnetized molecular clouds at scales of a few hundred AU; gravity has overcome magnetic support and the magnetic field traces a clear hourglass shape. The magnetic field is substantially more important than turbulence in the evolution of the system and the initial misalignment of the magnetic and spin axes may have been important in the formation of the binary system.

ASTE Observations of the Massive-Star Forming Region Sgr B2: A Giant Impact Scenario

Tetsuo Hasegawa, NAOJ,
Takaaki Arai, Univ. Tokyo , Nobuyuki Yamaguchi, NAOJ, Fumio Sato

We report mapping observations of an $\sim$ 40 pc $\times$ 40 pc region covering the Sgr B2 molecular cloud complex in the ^{13}CO (3-2) and the CS (7-6) lines with high angular resolution. The central region was mapped also in the C^{18}O (3-2) line. The images not only reproduce the characteristic structures noted in the preceding millimeter observations (Hasegawa et al 1994, Sato et al. 2000), but also highlight the interfaces of the molecular clouds with large velocity jumps of a few km s^{-1}. This new result further supports the scenario that a collision between giant molecular clouds has triggered the formation of massive stars in Sgr B2.

Unveiling the chemistry of hot protostellar cores with ALMA

Michel Guélin, IRAM,
Nathalie Brouillet, Obs. Bordeaux, José Cernicharo, DAMIR, Françoise Combes, Obs Paris, Alwyn Wooten, NRAO

Recent progresses in the measurement of molecule formation rates at low temperatures, in the gas phase and on grain surfaces, have enabled the development of sophisticated models of interstellar chemistry. This applies more particularly to the rich chemistry of hot protostellar cores, where grain-surface and gas-phase molecule formation are followed through the different phases of core evolution. Unfortunately, the astronomical data available for these sources are not up to the level of the models, which can hardly be tested on real data and exploited. The main reasons for this are lack of sensitivity and, mostly, lack of angular resolution. Most of the data obtained so far on hot cores comes from single-dish telescopes, which cannot resolve the sources and which, in multiple cores, mix up components in different evolutionary phases; the few available interferometric maps are sensitivity limited, except perhaps for the brightest sources. The inadequacy of single-dish telescopes (when not coupled with interferometers) and the need of high sensitivity will be illustrated in the case of the Orion-KL hot core, where we have recently obtained sensitive data with the GBT, the IRAM 30-m telescope and the IRAM Plateau de Bure interferometer, in the course of a search for glycine. The interefrometer maps resolve the Orion hot core and compact ridge into several small size cores, or corinos, with different chemical compositions. ALMA, which combines very high angular resolution and high sensitivity, will allow to extend this type of work to weaker and more distant sources. It will be the key instrument for protostellar chemistry studies.

Observational signatures of planet formation: The ALMA view *(invited)*

Nagayoshi Ohashi, Academia Sinica Institute of Astronomy & Astrophysics

Protoplanetary disks are most probable sites where planet formation take place. Planet formation in protoplanetary disks would expect to show remarkable signatures, such as a gap/hole or a spiral structure. In fact, recent high angular and sensitivity observations in mm- and submm-wavelengths start showing such structures in protoplanetary disks. In my talk, I will review recent observations of protoplanetary disks showing signatures of possible planet formation, with an emphasis on results obtained using the Submillimeter Array.

Detecting Protoplanets with ALMA *(invited)*

Sebastian Wolf, Max Planck Institute for Astronomy

Planets are expected to form in circumstellar disks, which are considered as the natural outcome of the protostellar evolution, at least in the case of low and intermediate mass stars. While a detailed picture of the evolution of the circumstellar environment, in particular of circumstellar disks, has been developed already, the planet formation process is in major parts still under discussion. In particular, adequate constraints from observations are required in order to either verify or rule out currently discussed planet formation scenarios. During recent years, numerical simulations and analytical studies of planet-disk interactions have shown that planets may cause characteristic large-scale signatures in the density distribution of circumstellar disks. The most important of these signatures are the warm local planetary environment, gaps, and spiral density waves in young, also called “protoplanetary” disks and resonance structures in evolved systems, so-called “debris disks”. The importance of investigating these signatures lies in the possibility to use them in the search for embedded planets. Therefore, disk features can provide constraints on the processes and timescales of planet formation. In this talk selected studies are summarized which demonstrate the capability of ALMA to observe the above features and thus to trace and to investigate planets during their formation and early evolution.

The study of young substellar objects with ALMA *(invited)*

Antonella Natta, Arcetri Observatory,
Leonardo Testi, Arcetri Observatory

This talk will review our current knowledge of the very low mass objects and brown dwarfs in star forming regions, of their disks and their evolution. The potential of observations with ALMA in the continuum and molecular lines will be examined.

A Submillimeter View of Protoplanetary Disks

Sean Andrews, University of Hawaii Institute for Astronomy,
Jonathan Williams, University of Hawaii Institute for Astronomy

We present some early results from our (sub-)millimeter aperture synthesis imaging survey of protoplanetary disks using the Smithsonian Submillimeter Array (SMA) on Mauna Kea. We use simultaneous fits to the spectral energy distributions and spatially resolved (sub-)millimeter continuum emission to constrain disk structure properties including surface density profiles and outer radii. Combined with a large multiwavelength single-dish survey of similar disks, we show how the observations provide evidence for significant grain growth and rapid evolution in the outer regions of disks, perhaps due to a photoevaporation process. In addition, we discuss our SMA observations of the Orion proplyds in the context of disk evolution in more extreme environments.

Observations of Dust in Molecular Clouds with ALMA *(invited)*

Doug Johnstone, NRC Canada, Herzberg Institute of Astrophysics

With the advent of multi-element submillimeter continuum array cameras on single-dish telescopes, large area mapping of the thermal emission from dust in molecular clouds has been investigated. These maps have shown that small-scale, thermally and gravitationally dominated, structure exists and appears intimately connected to the process of star formation. Indeed, the mass function of the dust (and gas) condensations is similar to the initial mass function for stars and the fraction of the cloud in this phase is similar to the expected star formation efficiency. While the large-scale maps provide significant statistical and environmental information, the resolution of ALMA is required to disentangle the physics involved in the star formation process. This is especially the case for regions where massive stars are forming. In this talk I will discuss the need for high angular resolution and sensitivity to constrain the radial density and temperature profiles of the envelopes - required inputs for all theories on how stars form. I will briefly discuss additional constraints that ALMA dust continuum observations will supply, including magnetic field measurements, opacity variations, and the connection between starless, possibly transient, features, and pre-stellar cores.

High angular resolution imaging of the circumstellar material around intermediate-mass stars

Asunción Fuente, Observatorio Astronómico Nacional, Spain

Intermediate-mass young stellar objects (IMs) (protostars and Herbig Ae/Be [HAEBE] stars with $M_* \sim$ 2 - 10 $M_\odot$) are crucial in star formation studies because they constitute the link between low- and high-mass stars. These objects share many characteristics with high-mass stars (clustering, PDRs) but their study presents an important advantage: there are many located closer to the Sun (d $\sim$1 Kpc), and in regions less complex than massive star forming regions. On the other hand, they are also important for the understanding of planet formation since Herbig Ae stars are the precursors of Vega-type systems. During the last 3 years, we have mapped a sample of intermediate mass young stellar objects in different evolutionary stages using the IRAM Plateau de Bure Interferometer (PdBI). In particular we have detected a IM hot core in the deeply embedded Class 0 object NGC 7129-FIRS 2. We have also imaged the borderline Class 0–Class I object IC1396-N using the A+ configuration of the PdBI which provides the highest angular resolution that can be achieved with the current millimeter instrumentation. These observations have allowed us to detect a "cluster" of hot cores/corinos and have a first glance at the evolutionary stage of each cluster component. Moving to more evolved objects, we have studied in detail the circumstellar disk associated with the Herbig Be star R Mon. ALMA will allow us to zoom in the intermediate-mass cores and study the circumstellar material at scales of $\sim$10 AU, a distance similar to the Saturn orbit around the Sun.

Revealing the “fingerprints” of the magnetic precursor of C-shocks.

Izaskun Jiménez-Serra, DAMIR-IEM-CSIC.,
Jesús Martín-Pintado, DAMIR-IEM-CSIC., Paola Caselli, Harvard-Smithsonian Center for Astrophysics., Tom Hartquist, University of Leeds.

We present the first modeling of the time evolution of the line profiles of SiO, molecular ions (HCO^+), and neutral molecules (HNC and HCN), as a C–shock propagates into the quiescent gas of dark clouds. To study the production of SiO along the C–shock evolution, we have developed a sputtering code in which the sputtering of grain mantles and grain cores is considered. We have included the sputtering yields of silicon on water grain mantles and olivine ($MgFeSiO_4$) grain cores, for the impact of H_2, He and other heavier atomic species like C, O, Si and Fe. These heavier species are shown to dominate the sputtering of grains at the first stages of the C–shock ($v \leq 10\,\mathrm{km\,s^{-1}}$). The study of the excitation of SiO and of the ion and neutral fluids of the gas, as well as the radiative transfer of the expected emission of these molecules, allows us to reproduce the evolution of the SiO, HCO^+, HCN and HNC line profiles from the initial magnetic precursor stage, to the final postshock equilibrium gas. The comparison of these results with interferometric and single–dish observations toward the very young L1448–mm bipolar outflow, will show that the intriguing narrow SiO emission and the enhancement of the electronic densities and the ion abundance in this outflow, constitute “fingerprints” of the magnetic precursor of C–shocks. The future high sensitivity and angular resolution provided by ALMA, will be crucial to study in detail the structure and the physical properties of the gas in the shock–precursor, and to characterize the grain processing at the first stages of the C–shock evolution.

Polarization measurements of molecular lines with ALMA *(invited)*

Richard Crutcher, University of Illinois

Polarization observations provide the only direct technique for studying astronomical magnetic fields. I will briefly describe two available techniques: measurements of circular polarization due to the Zeeman effect, and measurements of linear polarization due to the Goldreich-Kylafis effect. I will then summarize our current knowledge based on these techniques. However, polarized fluxes of spectral lines are always much weaker than total intensity fluxes, so sensitivity is a major limitation. The talk will conclude with an analysis of the expected ALMA sensitivity for observations of polarization in spectral lines and how that greatly improved sensitivity over existing millimeter-wave arrays should lead to significant advances in our understanding of interstellar magnetic fields.

Observations of Protostellar Cores with ALMA *(invited)*

M. Tafalla, Observatorio Astronómico Nacional, Spain

The last several years have seen enormous progress in our understanding of dense cores, the simplest sites of star formation. Previous contradictions between observations made in different tracers are now known to arise from a combination of chemical inhomogeneities and optical depth effects. Taking these elements into account, it has finally become possible to model self-consistently the internal structure of starless cores, and to use this structure to derive observationally the initial conditions of low-mass stellar birth. Despite the rapid and recent progress in the field of low-mass dense cores, many question still remain due to limited sensitivity and resolution of the current generation of single dishes and interferometers. The coming on-line of ALMA promises to revolutionize this field. It will allow observations with an unprecedented resolution of cores in the most nearby clouds, and it will make possible for the first time to systematicly study cores in a variety of clouds and large distances from our Solar System.

ALMA and the Galactic Center *(invited)*

Jesús Martín Pintado, DAMIR-IEM/CSIC Madrid

The Galactic center (GC) offers the opportunity to study in detail the processes which dominate the heating and the chemistry of the dense molecular gas and the formation of cluster of massive starts in galactic nuclei. Within $\sim$200 pc of the dynamical center of the Galaxy, in the molecular zone, there are a variety of energetic phenomena (non-thermal filaments, large scale shocks, huge photodissociation regions illuminated by the clusters of massive stars, a strong x-ray background emission) which have different effects in the ionization, heating and chemistry of the molecular clouds in the GC. I will present recent results on the study of the chemical complexity of the molecular gas in the in the GC. The chemical complexity observed in different regions in the GC will be used as templates to compare with those found in nearby Galaxies to establish the main mechanism which drives the chemistry in these galaxies. ALMA will be crucial to understand the properties of the dense molecular clouds in the GC in which massive star formation is taken place.

Molecular Clouds and Star Formation in the Magellanic Clouds and the Milky Way *(invited)*

Akiko Kawamura, Nagoya University

The Magellanic system consisting of LMC, SMC, the Bridge offers an ideal laboratory to study the properties of the molecular clouds because of its unrivaled proximity to us. It also has lower metallicities than the Milky Way and has a potential to tell how star formation may change depending on the metallicity. I will summarize recent studies of the molecular clouds and star formation in the Magellanic system obtained by NANTEN, ASTE and Spitzer, and will compare with those in the Milky Way.

Laboratory Data, Line Confusion and Other Unique Opportunities and Challenges for ALMA Line Surveys *(invited)*

John C. Pearson, Jet Propulsion Laboratory , California Institute of Technology

Millimeter and submillimeter spectroscopy in both the laboratory and in astronomy have historically relied on carefully measurement and interpretation of a few molecular lines. The enormous technological advances incorporated in ALMA render the one or two line observations obsolete for all but the dimmest most distant sources. The resulting paradigm shift will require novel tools for molecular astrophysics as well as novel approaches to spectroscopic laboratory work needed to support observations. ALMA will generate 16 GHz of line survey, often at or near the line confusion limit, for rich molecular sources per local oscillator setting. Effectively assigning and then interpreting this deluge of spectral information requires unprecedented completeness of laboratory data, computer aided tools for assignments and a means of actually fitting chemical, dynamical and radiative transfer models to the data quickly in a single processing environment. Rotational spectroscopy must adopt a number of techniques developed for vibrational and electronic spectroscopy where most or all of a molecular band is interpreted at once extracting global information. The same approach must be applied to both laboratory and astronomical spectra to beat line confusion and discover the most interesting weak features. For astronomical spectroscopy this will require an unprecedented completeness of databases and for laboratory spectroscopy this will require complete spectra with amplitude calibration facilitating computer aided assignments. How this might be accomplished in the current funds constrained environment will be discussed.

Chemistry in the ISM: The ALMA Revolution *(invited)*

Eric Herbst, Ohio State University

The field of astrochemistry is now almost 40 years old and has had many successes both in the understanding of molecular processes and the use of molecules as probes of the interstellar and circumstellar media. Increasingly detailed models of the chemistry of diverse objects are being constructed, some of which contain gas-phase reactions only while others also contain processes involving dust particles. Although some modellers include the heterogeneity of sources and dynamical effects in their models, it is fair to say that much of astrochemistry, despite its chemical complexity, is built upon simple and time-independent physical structures. The unparalleled spatial resolution that ALMA will achieve, however, should change the paradigm of chemical investigations from a relative neglect of small-scale and time-dependent physical features to a focus on them.

Complex Organic Molecules in an Early Stage of Protostellar Evolution

Nami Sakai, The University of Tokyo,
Takeshi Sakai, Nobeyama Radio Observatory, Satoshi Yamamoto, The University of Tokyo

Complex organic molecules such as $HCOOCH_3$ and C_2H_5CN have been detected exclusively in hot cores of active star forming regions, and are key molecules to diagnose in the densest part of star forming regions. In their production, the grain surface chemistry is thought to play an important role. Recently these complex organic molecules have also been detected toward four low mass star forming regions including our result, NGC1333IRAS4B (Sakai et al. 2006). These results clearly established the existence of “hot cores” even in a low mass star forming region. Furthermore these four sources are all the class 0 protostars. Particularly NGC1333IRAS4B is reported to be extremely young (a few 100 yr) according to the dynamical age of the molecular outflow (Choi 2001). So the complex organic molecules appear from the very early stage of protostellar evolution, and their spectral lines could be used as a novel tracer for detecting an onset of star formation. Very recently we have found a similar trend in a massive star forming region, NGC2264, by using Nobeyama 45 m telescope and NMA. We found that the $HCOOCH_3$ emission is almost absent toward NGC2264IRS1, whereas it is concentrated near NGC2264MMS3, which is reported to be younger than IRS1. In addition, we found that the $HCOOCH_3$ intensity peak is slightly shifted from the dust emission peak, as is seen in the Orion-KL compact ridge. Since NGC2264 is relatively close to the Sun (800 pc), we can obtain the second sample of the well resolved distribution of $HCOOCH_3$. This would also give us an important clue to solve the origin of compact ridge.

Dense Cores in the Massive Star Forming Region NGC6334

Diego Mardones. Universidad de Chile,
Diego Muñoz, Harvard University, Kate Brooks, ATNF, Guido Garay, Universidad de Chile, Sylvain Bontemps, Universite Bordeaux 1

We report observations of dust continuum emission towards the star forming region NGC 6334 made with the SEST SIMBA bolometer array. The observations cover an area $\sim 1^\circ \times 3^\circ$ with approximately uniform noise. We detect 181 clumps spanning almost three orders of magnitude in mass and sizes in the range 0.1-1.0 pc. We derive the overall differential clump mass function of the form $dN/d\log M \propto M^{-0.6}$ (or $dN/dM \propto M^{-1.6}$) which is in agreement with mass spectra from molecular line emission surveys. The Cumulative Mass Distribution Function is also computed with consistent results in the range of masses far from the high- mass cutoff where the power-law fit is no longer valid. The masses and sizes of these clumps indicate that they are not direct progenitors of stars; the process of fragmentation must eventually determine the distribution of stellar masses. A power law fit to the surface density of companions was obtained to be $\Sigma \propto \theta^{-0.21}$. The spatial distribution of these clumps reveals some clustering which is weaker than the one found for young stars in other star forming regions, suggesting that in the transition from clumps to cores the scale-free nature of the cloud structure reflected in Σ could suffer from a break at a characteristic length smaller than our resolution. NGC6334, at a distance of 1.7 kpc will be a primary target for star formation studies with ALMA.

A New Evolutionally Scenario of Intermediate-mass Starformation revealed by Multi-wavelength Observations of OMC-2/3

Satoko Takahashi, The Graduate University for Advanced Studies,
Masao Saito, NAOJ (ALMA Project Office), Shigehisa Takakuwa, NAOJ (ALMA Project Office), Ryohei Kawabe, NAOJ (ALMA Project Office)

We have newly performed a survey of millimeter- and submillimeter-wave observations using the Nobeyama millimeter array (NMA) and the Atacama Submillimeter Telescope Experiment(ASTE) in one of the nearest intermediate-mass star-forming regions; Orion Molecular Cloud -2/3 region(OMC-2/3). Using the high-resolution capabilities offered by the NMA, we observed dust continuum and $H^{13}CO^{+}$(1-0) emission in $\sim$15 protostellar candidates identified previously in single-dish millimeter observations. We successfully classified these protostars into four evolutional phases, (i) starless core phase, (ii) main accretion phase, (iii) core dispersing phase, and (iv) pre-Herbig Ae star phase We, furthermore, observed the entire OMC-2/3 region with the ASTE to search for large-scale molecular outflows associated with these protostars candidates observed with the NMA. As a result of the CO(3-2) observations, we detected 12 molecular outflows and four of these sources are newly identified. We found that the properties of the molecular outflows are closely related to the core evolutionally phase; from (ii) to (iv). The extremely high sensitivity and angular resolution offered by ALMA will reveal unprecedented details of the inner $\sim$ 50 AU of these protostars, which will provide us a break through in the classic scenario of intermediate-mass star/disk formation.

Scientific Role of ACA in the ALMA Project for the Field of Star Formation

Shigehisa Takakuwa,
Daisuke Iono, Baltasar Vila-Vilaro, Ryohei Kawabe, ALMA Project Office National Astronomical Observatory of Japan

In this talk, we will discuss the scientific role of the Atacama Compact Array (ACA), the Japanese contribution to the ALMA project, in the field of star formation. Our talk consists of two topics. First, we will present our recent observational results of several low-mass protostellar envelopes in the submillimeter CS (7–6) and HCN (4–3) lines with the Submillimeter Array (SMA) and Atacama Submillimeter Telescope Experiment (ASTE). We stress here that these submillimeter emissions are extended more than $\sim$ 2000 AU and show different velocity structures from those traced in millimeter lines in the low-mass protostellar envelopes, which suggests the importance of taking short spacing informations. Second, we will present our imaging simulations of these protostellar sources, and other sources such as merging galaxies and Sunyaev-Zeldovich effects, with ACA. These observational results and simulations unprecedentedly demonstrate the scientific importance of ACA. We also propose that taking cross correlations between the ALMA 12-m array and the ACA 7-m array, so called "combined array", is the most effective scientific usage of ACA and ALMA.

ALMA Observations of Solar System Bodies *(invited)*

Bryan J. Butler, NRAO

Because of its sensitivity, resolution, and wavelength coverage, ALMA will be a superb instrument for studying solar system bodies. Such studies will allow for a more complete understanding of the properties and history of these bodies, especially when observations using ALMA are combined with those from other wavelength regions, including radio (EVLA), and OIR (Keck, VLT, LSST, and JWST for example), and with spacecraft data. Every class of solar system object will be a target for ALMA observations, including the Sun, giant and terrestrial planets, large and small icy bodies (satellites, comets, TNO/KBOs, etc.), and asteroids. I will give an overview of the capabilities of ALMA with respect to solar system bodies, with some examples of specific studies which might be carried out.

The study of planetary atmospheres with ALMA *(invited)*

Emmanuel Lellouch, LESIA-Observatoire de Paris

Heterodyne spectroscopy at mm/submm wavelengths has proven over the last 20 years to be a powerful tool to study planetary atmospheres. The high spectral resolving power allows the detailed investigation of line shapes, providing information on the atmospheric temperature structure and the vertical profiles of molecular abundances, and, when the source is resolved, allowing direct wind measurements from the determination of Doppler shift of line cores. While large single-dish telescopes and current interferometers already permit a modest resolution of the largest of these bodies (Mars, Venus, Jupiter), ALMA will permit to resolve the planetary disks down to scales of $\sim 0.1 - 0.2''$, i.e. 100-1000 kilometers, depending on the object distance. In this manner, ALMA will be a unique tool to provide a three-dimensional dynamical picture (composition, temperature and wind fields) of planetary atmospheres. We will review the major science objectives, which include (i) the monitoring of the dynamics of the middle atmospheres of Mars and Venus (ii) the detailed study of Mars' H_2O and HDO cycle (iii) the search for new compounds in the martian and venusian atmospheres (iv) studies related to the origin of oxygen in outer Planet atmospheres (v) the mapping of the Giant Planet tropospheres in terms of temperature, ammonia, and phosphine abundances (vi) the detailed study of the composition and dynamics of the atmosphere of Titan, including the mapping of several nitriles (HCN, HC_3N, CH_3CN), the search for more complex molecules, and the determination of the wind structure (viii) the study of tenuous atmospheres, (Io, Pluto, Triton).

The study of comets with ALMA *(invited)*

Dominique Bockelée-Morvan, Observatoire de Paris

The millimetre and the submillimetre domain has proven to be a powerful tool to study the molecular and isotopic composition of cometary atmospheres, and characterize a number of processes that lead to its development and physical properties. In the light of results obtained this last decade using single-dish telescopes and the IRAM Plateau de Bure interferometer, I will present the prospect for cometary science with ALMA. This includes 1) the identification of new molecular species and measurements of key isotopic ratios, 2) the investigation of the chemistry of Kuiper Belt comets and the comparison with Oort cloud comets, 3) the imaging of gas jets and their relation with dust features, 4) the investigation of extended sources of gas in the coma, and 5) the study of the dust coma and nucleus physical properties.

Observation of Asteroids with ALMA *(invited)*

Amy Lovell, Agnes Scott College

Thermal observations of large asteroids at millimeter wavelengths have revealed rotational lightcurves with high amplitudes. Such lightcurves are important constraints on thermophysical models of asteroids, and provide unique insight into the nature of their subsurfaces. The high sensitivity of ALMA will enable us to obtain lightcurves for a large sample of main-belt and near-Earth objects, opening the possibility for classification of these bodies based on thermal characteristics. Of particular interest are the near-Earth objects, which can be observed at large phase angles, permitting better assessment of the thermal response of their unilluminated surfaces. The high spatial resolution of ALMA will also enable tighter constraints on thermal properties by region across the larger objects. A better understanding of asteroid surfaces provides insight into the composition, physical structures, and processing history of these surviving remnants from the formation of our solar system. In addition, detailed observations of the larger asteroids, accompanied by thermophysical models with appropriate temporal and spatial resolution, promise to decrease uncertainties in their flux predictions. Those with known shapes and well-characterized lightcurves can then be employed for flux calibration by ALMA and other high frequency instruments. Although the number of asteroids appropriate for use in flux calibration will be limited, such bodies would generally be well-distributed across the sky, and easily observed from the latitude of ALMA.

ALMA as the ideal probe of the solar chromosphere

Maria Loukitcheva, Max-Planck-Institut fuer Sonnensystemforschung, St. Petersburg University, Sami Solanki, Max-Planck-Institut fuer Sonnensystemforschung, Stephen White, University of Maryland

The chromosphere remains the least understood layer of the solar atmosphere, with the very basics of its structure being hotly debated: is it better described by the classical picture of a steady temperature rise as a function of height, with superposed weak oscillations, or does the temperature keep dropping outwards, with very hot shocks producing strong localized heating? In addition, its thermal structure is also affected by the magnetic field in an unknown way. Observations in the UV and the IR give contrasting results, since they only sample either the hot or the cool parts of the chromosphere. Computations carried out with a sophisticated dynamic model of the solar chromosphere due to Carlsson and Stein demonstrate that millimeter emission is extremely sensitive to dynamic processes in the chromosphere and the appropriate wavelengths to look for dynamic signatures are in the range 0.8-5.0 mm. The model also suggests that high resolution observations at mm wavelengths, as will be provided by ALMA, will have the unique property of reacting to both the hot and the cool gas, and thus will have the potential of distinguishing between rival models. Initial results obtained from the observations of the quiet Sun at 3.5 mm with the BIMA array (resolution of 12 arcsec) reveal significant oscillations with amplitudes of 50-150 K and frequencies of 1.5-8 mHz with a tendency toward short-period oscillations in internetwork and longer periods in network regions. However higher spatial resolution is required for a clean separation between the features within the solar atmosphere and for an adequate comparison with the output of the comprehensive dynamic simulations.

Millimeter and Submillimeter Observations of Uranus and Neptune

Mark Hofstadter, JPL,
Bryan Butler, NRAO, Mark Gurwell, SAO, Glenn Orton, JPL

We are observing Uranus and Neptune using the Very Large Array (VLA) and the Submillimeter Array (SMA). Both continuum and spectral line data that spatially resolve the planets are being collected in order to study the temperature and composition of the atmosphere. This allows us to infer the radiative and dynamical state in and around the tropopause, an important transition zone where the atmosphere changes from being radiatively to convectively dominated. A comparison of the two planets is interesting because Uranus' extreme tilt (obliquity 82 degrees) causes it to have a very different solar insolation pattern than Neptune, but otherwise the planets are very similar. The current epoch is also a particularly interesting time to observe these planets, as Uranus is approaching its equinox and Neptune a solstice, which may be times of unusual atmospheric activity (Klein and Hofstadter 2006, Icarus 184; Sromovsky et al. 2003, Icarus 163). Results will be compared to recent work on Uranus at 1 to 20 cm which suggests atmospheric circulation responds to seasonal changes in sunlight more rapidly and to deeper levels than expected (Hofstadter and Butler 2003, Icarus 165), and to visible and near-IR data that shows both temporal and spatial variations in cloud patterns and activity (Hammel et al. 2005, Icarus 175). In this talk, we will present our most recent observations (made in the summer and fall of 2006), and discuss the exciting opportunities ALMA will provide to further our understanding of giant planet atmospheres.

The study of evolved stars with ALMA *(invited)*

Hans Olofsson, Onsala Space Observatory and Stockholm Observatory

Extensive post-main sequence mass loss occurs for low- and intermediate-mass stars on the asymptotic giant branch (AGB), and for the higher mass stars during their red supergiant evolution. These winds affect the evolution of the stars profoundly, as well as the enrichment of the interstellar medium with heavy elements and grain particles. The mass loss on the AGB is the by far most well-studied, but the basic processes are still not understood in detail, or cannot be described in a proper quantitative way, e.g., the mass loss mechanism itself. These objects also provide us with fascinating systems, in which intricate interplays between various physical and chemical processes take place, and their relative simplicity in terms of geometry, density distribution, and kinematics makes them excellent astrophysical laboratories. In this review I will concentrate on the aspects of AGB mass loss which are of particular interest in connection with ALMA.

The Molecular Content and Physical Structure of Protoplanetary Nebulae *(invited)*

Valentín Bujarrabal, Observatorio Astronómico Nacional

Planetary nebulae (PNe) are formed in a very fast process. In just about 1000 years, the nebula evolves from a spherical and slowly expanding AGB envelope to a PN, with usually axial symmetry and high axial velocities. The observation of molecular lines is the best tool to study protoplanetary nebulae. Existing observations probe both the gas accelerated by post-AGB shocks and the quiescent components. But the study of the crucial regions to understand PN formation (recently shocked shells, regions heated by the stellar UV and inner rotating disks) requires observations at higher frequency and with still better spatial resolution.

Planetary Nebulae and ALMA *(invited)*

Patrick Huggins, New York University

Our understanding of the final evolution of intermediate and low mass stars through the planetary nebula (PN) phase has undergone recent major developments. Observations at infrared and millimeter wavelengths have revealed an important component of neutral gas and dust in PNe that links their formation with mass-loss on the Asymptotic Giant Branch. At the same time, high resolution imaging, especially with the Hubble Space Telescope, has revealed a surprising array of structures in PNe that are formed in these final phases: multiple arcs, disks, jets, and myriads of small scale fragments. None of these structures are fully understood, and they all involve the neutral gas component. This paper reviews recent observations of these features in PNe and discusses open questions, with an emphasis on those areas where observations with ALMA are likely to make important contributions.

Chemistry in the ISM : Unveiling the dust formation zone *(invited)*

Tom Millar, Queen's University Belfast

In this talk, I will review the formation pathways of dust in carbon-rich and oxygen-rich AGB stars and discuss the observational consequences of dust formation both in AGB stars and in the interstellar medium.

A massive bipolar outflow and a dusty torus with large grains in the PPN IRAS 22036+5306

Raghvendra Sahai, JPL,
K. Young, CfA, N.A. Patel, CfA, Carmen Sánchez-Contreras, IEM, Mark Morris, UCLA

We report high angular resolution (1″) CO 3-2 interferometric mapping using the SMA of IRAS 22036+5306, a bipolar PPN with knotty jets discovered in our HST snapshot survey. The observations show the presence of a very fast (220 km s^{-1}) highly collimated, massive (0.03 $M_\odot$) bipolar outflow with a very large scalar momentum (10^{39} g cm s^{-1}, and the characteristic spatio-kinematic structure of bow-shocks at the tips of the outflow. We also find an unresolved source of submillimeter continuum emission implying a very substantial mass (0.04 $M_\odot$) of (large ($>$ 1 mm), cold ($>$ 50 K) dust grains associated with the toroidal waist. The combination of high circumstellar mass and the high $^{13}CO/^{12}CO$ ratio provides strong support for this object having evolved from a massive ($>$ 4 $M_\odot$) progenitor in which hot-bottom-burning has occurred.

Understanding the chemical complexity of the Circumstellar Envelopes of C-Rich AGB stars: The case of IRC+10216

M. Agúndez, DAMIR, IEM, CSIC,
J. Cernicharo, DAMIR, IEM, CSIC, J. R. Pardo, DAMIR, IEM, CSIC, M. Guélin , IRAM Grenoble, E. D. Tenenbaum, University of Arizona L. M. Ziurys, University of Arizona, A. J. Apponi, University of Arizona

The circumstellar envelope of C-rich AGB stars shows a chemical complexity that is exemplified by the prototypical object IRC+10216, in which up to 59 molecular species have been detected to date. These species consists of carbon chains of the type C_nH, C_nH_2, C_nN, HC_nN. Particularly surprising has been the recent detection of oxygen bearing species such as H_2O, OH and H_2CO. We present the detection of new species (CH_2CHCN, CH_2CN, H_2CS and C_3O) achieved thanks to the systematic observation of the full 3 mm window with the IRAM 30m telescope plus ARO 12 m observations. All these species, known to exist in the interstellar medium, are detected for the first time in a circumstellar environment. Particularly interesting is C_3O, which is the seventh O–bearing species detected in the carbon star IRC+10216. Most of the molecules are produced in the outer circumstellar envelope due to the combined effect of (i) photodissociation and production of radicals followed by (ii) rapid radical–molecule gas phase reactions. The reactions between two radicals (e.g. between atomic oxygen and hydrocarbon radicals) are very difficult to measure in the laboratory since both reactants are unstable species under terrestrial conditions. However, some of these reactions may proceed rapidly at low temperatures, thus playing an important role in the chemistry of the outer envelope. The high spatial resolution and sensitivity of ALMA interferometer will permit to see the exact region of the envelope where all these molecules, some of them detected through rather weak lines, are produced and to understand the underlying chemistry.

New Plateau de Bure observations of M1-92: unveiling the core

Javier Alcolea, OAN,
Roberto Neri, IRAM, Valentín Bujarrabal, OAN

When moderate mass stars run out of Helium at their cores, they grow enormously turning into red-giants. While in this AGB phase, stars loose their mantle, which is gently expelled into space at an increasing rate, forming a spherical cloud of gas and dust: a circumstellar envelope (CSE). By the end of the AGB, this mass loss is very heavy, up to 10^4 $M_\odot$/yr, becoming the main driving mechanism of the stellar evolution. In about 10^4 yr, the whole mantle is lost and the exposed stellar core floods with UV light the CSE, which becomes a Planetary Nebula (PN). HST precise imaging shows that PNe are among the most bizarre objects in space: in practice no two are alike. How these complex structures may result from the evolution of simple balls of dust and gas around normal stars is one of the great mysteries in modern Astrophysics. To understand this shaping process we must examine the transient objects, the pre-Planetary Nebulae (pPNe), which are nebulae around post-AGB stars but not yet at the PN phase. Since 1994 we have been studying one of pPNe's best examples, M1-92, obtaining HST, VLA, and Plateau de Bure (PdB) images of line and continuum emission. M1-92 has been stretched and accelerated along its axis of symmetry 900 yr ago, as a result of a violent event of unknown energy origin. We present our latest results obtained with the new extended PdB array. The 0.35 ″. resolution maps of the ^{13}CO J=2-1 line show that the inner regions of this pPN present evidences of not being just in expansion, but maybe orbiting the central star. If true, this would relate PNe shaping with other astrophysical problems where rotation and axial flows are linked.

An overview of Galaxy Formation with ALMA *(invited)*

Linda Tacconi, Max-Planck-Institut fuer extraterrestrische Physik, Garching, Germany

In standard cold dark matter cosmology galaxies form as baryonic gas cools at the centre of collapsing dark matter halos. Mergers of halos and forming galaxies within them are key drivers of the hierarchical growth of galaxy mass. The details of galaxy assembly are still unclear, however, and ALMA will be a primary tool for answering some of the many outstanding questions: When and how were the first disks formed? How are disk and bulge formatio related? What are the roles of feedback from energtic starbursts and AGN? How are central massive black holes grown? Many of these and other important questions will be answered by studying the distributions, dynamics and physical properties of the cool gas and dust with ALMA. In this talk, I will focus on studies of galaxies at redshift 2-3, the epoch of the peak of star formation and QSO activity. I will attempt to assess the impact that ALMA will have by giving examples from ongoing studies of galaxies with current mm interferometers and AO-assisted IR integral field spectrometers.

Gas Dynamics and Structure of Galaxies *(invited)*

Kazushi Sakamoto, NAOJ

Gas dynamics in a spiral galaxy is determined, in short timescale, by the structure of the galaxy — such structures as the bulge, disk, halo, bar(s), and spiral arms mostly decide how cold gas moves and where it concentrates in the galaxy. The distribution and motion of the cold ISM strongly influence, if not determine, star formation in the galaxy. At the same time, gas can alter the galaxy structure in long timescale through the star formation from gas and through redistribution of mass within the galaxy. This has been suggested to cause secular evolution of spiral galaxies — a slow mode of galaxy evolution without major mergers. Our understanding of these processes is going to be greatly advanced by the ALMA. I introduce what we know about this fascinating subject, addressing recent results such as those from the existing mm/sub-mm facilities, and try to project what the ALMA can do to answer open questions in the field.

Star Formation in Galaxies using ALMA *(invited)*

Min Yun, University of Massachusetts

ALMA provides unprecedented sensitivity and resolution to study gas and dust emission in the millimeter and submillimeter bands. The magnitude of the improvement is such that not only the conventional studies can be done much better but also entirely new tools and research fields should open up. I will discuss some of the intriguing possibilities using some early examples of the types of data ALMA should produce.

Chemical Complexity in Galaxies *(invited)*

J. L. Turner, UCLA

It has been known for some time that galaxy-wide chemical differences exist, due to environmental influences such as starbursts. Radiation fields, metallicity, and star formation rates can all have widespread effects on the properties of molecular clouds. Interferometry can refine our understanding of what processes effect cloud chemistry within galaxies; in local galaxies it is even possible to resolve individual GMCs with existing millimeter and submillimeter interferometers. Simultaneous imaging of many molecular lines allows spatial information to be combined with chemical information in a statistical context, to clearly and objectively identify regions dominated by particular types of chemistry, such as shock-driven chemistry, PDR chemistry, quiescent gas chemistry. In turn, from the spatial distribution of molecular line emission, the presence of shocks and other conditions related to galactic structure can be inferred. Interferometric imaging surveys of molecules therefore have the potential of informing us not only about the chemistry of molecular clouds in different environments, but also of the specific physical and dynamical processes occurring in diverse galactic environments. ALMA has great potential for informing us about the star formation process and its feedback in diverse galactic environments.

The Galactic Center as nearby extragalactic chemical laboratory through molecular line surveys

Sergio Martín, Harvard-Smithsonian Center for Astrophysics,
Miguel Angel Requena-Torres , DAMIR, IEM-CSIC, Jesús Martín-Pintado, DAMIR, IEM-CSIC, Rainer Mauersberger, IRAM

The avalability of wideband receivers altogether with the high collecting area of ALMA will easily cover large spectral regions, allowing us to create full molecular line surveys of a wide variety of extragalactic objects, far from our present reach. This observations will provide a full chemical description of a large number of galaxies with different morphologies and evolutionary stages. The recently published 2mm line survey towards the starburst galaxy NGC 253 has shown the need of chemical templates within the Galaxy in order to fully understand molecular emission within the nuclear region of galaxies. It will be shown how the study of the chemical complexity of molecular cloud prototypes within the Galactic Center region may provide a key information to determine the heating mechanisms of molecular material in the nuclei of galaxies. This is particularly important in sources such as submillimeter galaxies not easily observable in other frequency ranges.

Probing the Feeding and Feedback of Activity in Galaxies Near and Far

Santiago Garcia-Burillo, Observatorio Astronomico Nacional (OAN)

Current mm-interferometers can zoom in on the scales of individual GMCs or GMAs in the circumnuclear disks of nearby galaxies, and have a complete view of the distribution and kinematics of their molecular gas reservoirs. The availability of high-resolution CO maps are key to track down the feeding of AGN and quantitatively address the issue of how and for how long nuclear activity can be sustained in galaxies. Going beyond CO mapping, the use of more specific molecular tracers of dense gas can probe the feedback influence of activity in the interstellar medium of nearby galaxies, a prerequisite to interpret how feedback may operate at higher redshift galaxies. In this context we will present the latest results issued from the NUGA project, a high-resolution (0.5”-1”) CO survey of low luminosity AGN conducted with the IRAM interferometer. We discuss an evolutionary scenario in which gravity torques and viscosity act in concert to produce recurrent episodes of activity during the typical lifetime of any galaxy. We will also present the results of an ongoing survey allying the IRAM 30m telescope with the Plateau de Bure Interferometer, devoted to probe the dense molecular gas in a sample including nearby AGNs and ULIRGs as well as two representative high-z galaxies. In the light of these results, we will discuss how diagnostic tools in the mm-range can help to identify and study embedded star formation and AGNs in the high-z Universe.

Chemistry in Active and Starburst Galaxies *(invited)*

S. Aalto, Chalmers University of Technology and Onsala Space Observatory, Sweden

I will discuss recent results on nuclear and extended molecular gas in interacting starbursts and AGNs - with a focus on physical conditions and chemistry. Molecular studies are particularly useful for probing the deeply enshrouded dusty nuclei of luminous infrared galaxies.Statistical surveys and targeted high resolution studies can be used to model the extreme SFE/SFR in the nuclei of starbursts and to explore the impact of an AGN on its surrounding gas. Recent results on Arp220 and NGC4418 will be presented.

Dense gas in nearby active and normal galaxies *(invited)*

Kotaro Kohno, U. of Tokyo,
Toshihito Shibatsuka, U. of Tokyo, Koichiro Nakanishi, NAOJ , Kazuyuki Muraoka, U. of Tokyo, Tomoka Tosaki, NAOJ, Rie Miura, U. of Tokyo, Masatoshi Imanishi, NAOJ, Ryohei Kawabe, NAOJ, Kazuo Sorai, U. of Hokkaido

We present two surveys of dense molecular gas in galaxies; one is a high resolution HCN(1-0), HCO^+(1-0) and CO(1-0) imaging survey of active galaxies made with Nobeyama Millimeter Array, and the other is a wide area CO(3-2) imaging survey of galaxies using the Atacama Submillimeter Telescope Experiment (ASTE), a 10 m dish in Atacama desert. The sample of the former survey consists of 20 Seyferts (6 type-1s and 14 type-2s) and 12 starbursts. Some of the observed Seyferts, such as NGC 1068, NGC 1097, NGC 5033, and NGC 5194, show strong HCN(1-0) emission at $\sim$ 100 pc scales; the observed HCN(1-0)/CO(1-0) and HCN(1-0)/HCO^+(1-0) line ratios in these Seyfert nuclei ($\geq$ 0.2 and $\geq$ 2, respectively) are never observed in nuclear starbursts. We suggest that the elevated HCN emission is originated from X-ray dominated regions (XDRs) close to the active nuclei, and our proposed diagram based on HCN(1-0)/HCO^+(1–0) ratios will be a powerful diagnostic of energy sources even in heavily dusty objects such as ULIRGs and SMGs, because these molecular lines are free from dust extinction. CO(3-2) is another tracer of dense molecular medium, and the ASTE was used to make wide area CO(3-2) images of M83, NGC 253, M33, and NGC 986. In M83, a $5' \times 5'$ wide map at a resolution of $22''$ was obtained. Together with a CO(1-0) map by the NRO 45m telescope and a VLA radio continuum image, we find a spatial correlation between CO(3-2)/CO(1-0) ratios and star formation efficiencies in M83, demonstrating the importance of large scale dense gas observations to understand the global star formation properties in galaxies.

Star formation in galaxies: multiwavelength insights *(invited)*

Michael Regan, Space Telescope Science Institute

Being able to estimate the current star formation rate in a galaxy is a critical measurement for understanding galaxy evolution. This is challenging when we want to derive the star formation history of the Universe back to the formation of the first stars and galaxies. Over such a large range in redshift it is not possible to use a single tracer that will work in the local Universe and at red shifts larger than 10. In this talk I will review some of the recent results of the Spitzer Infrared Nearby Galaxies Survey (SINGS). This survey has a primary goal of calibrating the various tracers of star formation from the ultraviolet to the radio. In particular I will show what we now know about the star formation tracers that we will be using with ALMA in the local and high redshift universe.

Spectroscopic Surveys of Cosmic Evolution *(invited)*

Nick Scoville, CalTech

I will summarize the directions which might be possible for large field spectroscopic surveys with ALMA of galaxy evolution at z = 0.5 to 4. ALMA will clearly play a pioneering role in studies of this epoch of major galaxy evolution – however, much of the evolution is dependent on environmental effects and gaalxy merging. Thus it will be vital to have full multi-wavelength coverage of large fields which sample all scales of structure.

Observations of molecular clouds in nearby galaxies with ALMA

Nario Kuno, Nobeyama Radio Observatory,
Akihiko Hirota, The University of Tokyo, Tomoka Tosaki, Nobeyama Radio Observatory

We present the results of the CO mapping survey of 40 nearby spiral galaxies with the NRO 45-m telescope. We investigated variation of SFE in some galaxies comparing with tracers of star formation. The bar regions tend to have low SFE, while central regions and strong spiral arms have higher SFE in some barred spiral galaxies. We also present recent results of observations of Giant Molecular Clouds (GMCs) in nearby galaxies with Nobeyama Millimeter Array (NMA). For example, CO observations of a spiral arm in IC 342 with high angular resolution are under way. We identified some GMCs whose size and mass are comparable with those in our Galaxy. The property of the GMCs seems to change crossing the arm, namely, the GMCs in downstream region are more gravitationally bound than those in upstream region. The place where the properties of the GMCs change may correspond to the galactic shock region. ALMA can resolve individual molecular cloud in nearby galaxies and investigate difference of properties of molecular clouds in various regions of galaxies such as central region, spiral arm, interarm and bar. Such observations must give us clues to find the reasons of the variation of SFE in galaxies and to understand massive star formation.

Luminous Infrared Galaxies with the Submillimeter Array: Probing the Extremes of Star Formation

Christine Wilson, McMaster,
Glen Petitpas, CfA, Alison Peck, CfA, Melanie Krips, CfA, Daisuke Iono, NAOJ, Andrew Baker, Rutgers, Paul Ho, ASIA-A, S. Matsushita, ASIA-A, M. Yun, UMass, T.J. Cox, CfA, B. Warren, McMaster, L. Armus, IPAC, Y. Pihlstrom

Luminous and Ultraluminous infrared galaxies (ULIRGs) contain the most intense regions of star formation in the local universe. Because molecular gas is the fuel for current and future star formation, the physical properties and distribution of the warm, dense molecular gas are key components for understanding the processes and timescales controlling star formation in these merger and merger remnant galaxies. I will present new results from a legacy project on the Submillimeter Array which is producing high resolution images of a representative sample of galaxies with log(LFIR) > 11.4 and D < 200 Mpc.

Large-scale extragalactic continuum surveys with ALMA *(invited)*

David Hughes, Instituto Nacional de Astrofísica, Optica y Electrónica - Mexico

ALMA's greatest capability is the extraordinary resolution at (sub-)mm wavelengths. I will concentrate my presentation, however, on the opportunities to map large-area fields with ALMA, and to study the early evolution of galaxies in both biased over-densities and "blank-fields" in the high-redshift universe. I will describe examples of scientific goals from high-redshift continuum ALMA surveys, and present them in the context of current and future generations of FIR-mm wavelength experiments.

Continuum observations of high-z objects *(invited)*

Frank Bertoldi, Bonn University

Blank field bolometer surveys and pointed observations of high-redshift quasars have revealed the most luminous infrared galaxies in the Universe, objects that trace violent bursts of star formation associated with massive galaxies in their early formation phases. Although they provide important insights on the agglomoration of massive structures, these ultra-luminous infrared galaxies are not representative of the average star formation in the early universe, and probably neither of the interplay between star formation and the growth of supermassive black holes. Only the enhanced sentitivity of ALMA will allow us to trace star formation in the less luminous but representative galaxies, and to systematically study its dependence on environment and nuclear activity.

Search for the most distant objects with ALMA *(invited)*

Fabian Walter, MPIA, Heidelberg

Detecting and studying objects at the highest redshifts is clearly a key science goal of ALMA, in particular given the latest results from the WMAP team that indicate that the reionization period took place in the redshift range of $6<z<11$. ALMA will in principle be able to detect objects in this redshift range both from high-J ($J>6$) CO transitions and CII, one of the main cooling lines of the ISM. ALMA will even be able to resolve this emission for individual targets, which will be one of the few ways to determine dynamical masses for systems in the Epoch of Reionization. I will discuss some of the current problems regarding the detection and characterization of objects at high redshifts and how ALMA will eliminate most (but not all) of them.

Multi-wavelength observations of very distant galaxies *(invited)*

Toru Yamada, Subaru Telescope

ALMA will provide great opportunities to search for the most distant galaxies through mm- and sub-mm emission. The most fascinating quests with ALMA will be (i) to search for the most distant (z 10) galaxies in thermal dust emission and (ii) to study detailed study of star-formation process and gas kinematics at the site of massive forming galaxies at moderate (z 1-5) redshift range. Clearly, multi-wavelength observation efforts including optical and infrared are essential to make such ALMA data very valid. In this talk, I will present our previous efforts mainly using Subaru Telescope of multi-wavelength study of distant galaxies and introduce a prospects for the deep and intensive multiwavelength study with ALMA.

ALMA and the high-z GRBs *(invited)*

Dale A. Frail, National Radio Astronomy Observatory

Gamma-ray bursts (GRBs) and their afterglows have been the subject of extensive multi-wavelength efforts, and yet they remain comparatively little-studied at millimetre and sub-millimetre wavelengths. In this review I will begin by summarizing our current understanding of gamma-ray bursts, their progenitors, central engines and their host galaxies. I will focus the remaining part of the review on unanswered questions, pointing out where ALMA may be able to make significant contributions.

Lyman alpha emitters at highest redshift. Extensive study in the field of starburst galaxies from nearby to high-z *(invited)*

Yoshiaki Taniguchi, University of Tokio

We present a summary of the recent progress in searching for Lyman alpha emitters at high redshift. The relation between Lyman alpha emitters and Lyman break galaxies is also discussed. After sumamrizing these issues, we discuss the cosmic star formation history viewed from extensive study in the field of starburst galaxies from high redshift to the local universe.

Observations of First Light with ALMA

C.L. Carilli, NRAO

The discovery of Gunn-Peterson absorption in the spectra of the most distant QSOs, and limits on the large scale polarization of the CMB, have set the first constraints on cosmic reionization, implying that the neutral IGM was reionized by the first stars and/or black holes between z = 6 to 11. ALMA will have the capability of detecting the molecular gas and dust, the requisit fuel for star formation, from this first generation of galaxies. I will review the most recent results on mm studies of the dust and gas in the host galaxies of the most distant QSOs (z>6), and then compare the capabilities of ALMA to other next generation ground and spaced based telescopes for studying the first light in the universe.

Is ALMA Going to See Many High-Redshift (z>4) Galaxies?

Wei-Hao Wang, University of Hawaii,
Lennox Cowie, University of Hawaii, Amy Barger, University of Wisconsin-Madison

The submillimeter (submm) extragalactic background light (EBL) maps the star formation history throughout the cosmic time. Deep blank-field SCUBA surveys are limited by confusion and have resolved only $\sim$30% of the submm EBL into point sources with fluxes brighter than $\sim$2 mJy at 850 μm. Furthermore, only $\sim$60% of these resolved bright submm sources have radio counterparts and can be followed up with optical spectroscopy. The majority (80%) of the submm EBL is either below the confusion limit of SCUBA or below the sensitivity limit of current radio interferometers. I will report our most recent studies of the submm EBL. We break through the above limits with stacking analyses on our deep 850 um SCUBA image in the GOODS-N. Using a deep near-IR sample, we detect at least 50% (or as much as 80%) of the total submm EBL. We find that the submm EBL mostly come from galaxies at redshifts around 1.0. This redshift is much lower than that (z=2-4) previously implied from radio identified SCUBA sources. The implication to planning ALMA surveys of high-redshift galaxies will be provided.

Molecular absorption measurements in high-z objects *(invited)*

Françoise Combes, Observatoire de Paris, LERMA

Molecular absorption lines measured along the line of sight of distant quasars are important probes of the gas evolution in galaxies as a function of reddshift. A handful of molecular absorbing systems have been studied intensively with the present sensitivity of mm instruments, and have produced information on the chemistry of the ISM at z *sim* 1, the physical state of the gas, in terms of clumpiness, density and temperature. The CMB temperature can be derived as a function of z, and also any possible variations of fundamental constants can be constrained. With the sensitivity of ALMA, many more absorbing systems can be studied, and I will describe some predictions and perspectives.

Cosmology and SZ with ALMA *(invited)*

Naoshi Sugiyama (Department of Physics & Astrophysics, Nagoya University, Japan)

I will discuss a possible detection of the Sunyaev-Zeldovich (SZ) effect by ALMA. The SZ effect induces temperature fluctuations on Cosmic Microwave Background (CMB) due to either the inverse Compton scattering of thermal high energy electrons off photons (thermal SZ) or Doppler motion of ionized clouds (kinetic SZ). The first star formation in the universe ionized surrounding medium. Ionization of these medium induces both thermal and kinetic SZ effects on CMB. It is expected that we can obtain temperature of the ionized medium from thermal SZ and peculiar motion of the ionized clouds. From different frequency dependences, we can separately observe two effects. These observations will be key probes for how and when the dark ages end and cosmic dawn starts.

Molecular gas in a large ULIRG sample: the low-redshift connection to the huge high-z starbursts and AGNs

Javier Graciá-Carpio, Observatorio Astronómico Nacional,
Santiago García-Burillo, Observatorio Astronómico Nacional, Pere Planesas, Observatorio Astronómico Nacional, Luis Colina, Instituto de Estructura de la Materia, CSIC

The sample of nearby ULIRGs for which molecular gas tracers has been measured is building up, allowing for the study of the physical, chemical and dynamical properties of the gas in the variety of objects in which the most intense star formation and/or AGN activity in the local universe is taking place. This characterization is essential to understand the processes involved, to discard others and to help to interpret the powerful starbursts and AGNs at high redshift that are currently being discovered and that will routinely be mapped by ALMA. We are studying a large sample of nearby ULIRGs covering the different stages of the interaction/merging process as well as the different nuclear activity from HII to Seyfert 1. We will present the results of our observations in lines of several molecules (CO, HCN, HCO+, CN, HNC & CS) that trace the different physical and chemical conditions in these extreme objects.

Molecular signatures of star formation at high redshifts

Serena Viti, University College London,
Chris Lintott, University College London, David Williams, University College London, Ignacio Ferreras, Kings College London, Jonathan Rawlings, University College London,

In recent years there has been much debate, both observational and theoretical, about star formation at high redshift. In particular, there seems to be strong evidence of a greatly enhanced star formation rate earlier in the evolution of the Universe. Simulations investigating the nature of the first stars indicate that these should be large, with masses in excess of 100 solar masses. By the use of a chemical model, we have simulated the molecular signatures of massive star formation for a range of redshifts, using different input models of metallicity in the early Universe. We find that, as long as the number of of massive stars exceeds that in the milky way by factor of at least 1000, then several 'hot-core' like molecules should have detectable emission. Although we predict that such signatures should already be partly detectable with current instruments (e.g. with the VLA), facilities such as ALMA will make this kind of analysis possible at the highest redshifts. In this talk we will present our simulations and we will make predictions for ALMA.

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280 **Near-IR to sub-mm observations of lensed $z>$ 6 galaxies and faint optical drop-outs** Frédéric Boone, Observatoire de Paris

281 **Radio-FIR photometric selection of high-z galaxies for ALMA** Itziar Aretxaga, David H. Hughes, J.S. Dunlop, et al.

282 **Detection of HCN and [CI] line emission in APM08279+5255 at z=3.91** Jeff Wagg (NRAO), David J. Wilner (CfA), Roberto Neri (Iram), Dennis Downes (Iram), Tommy Wiklind (STScI)

283 **MAMBO sources in the COSMOS field: Studying extreme high-z starburst galaxies.** Manuel Aravena, AIfA-MPIfR, F. Bertoldi, AIfA-MPIfR, C. Carilli, NRAO, E. Schinnerer, MPA, H. Voss, MPIfR, V. Smolcic, MPA, N. Scoville, CalTech, A. Blain, CalTech, K. M. Menten, MPIfR, D. Lutz, MPE, M. Brusa, MPE, Y. Taniguchi, U Tokio

284 **The predicted H_2 density at high redshift for spiral and irregular galaxies** Mercedes Mollá, CIEMAT, Madrid, Angeles I. Díaz, UAM, Madrid, Eduardo Hardy, NRAO, Chile

285 **Ammonia absorption lines towards B0218+357 and PKS 1830-211** N. Jethava, MPIfR, C. Henkel, MPIfR, K. M. Menten, MPIfR

286 **High-Resolution Imaging of Molecular Gas in High-Redshift Quasar Host Galaxies** Dominik A. Riechers (MPIA Heidelberg), , Fabian Walter (MPIA Heidelberg), , Christopher L. Carilli (NRAO Socorro), , Frank Bertoldi (AIfA Bonn), , Pierre Cox (IRAM Grenoble)

287 **First Light Spectra with ZEUS** Steven Hailey-Dunsheath, Cornell University, T. Nikola, Cornell University, G.J. Stacey, Cornell University, T. Oberst, Cornell University, S. Parshley, Cornell University, D.J. Benford, NASA GSFC, S.H. Moseley, NASA GSFC, J.G. Staguhn, NASA GSFC

Abstracts of poster contributions

101 Astrometry Using ALMA

Ed Fomalont, NRAO

Although the maximum baseline of ALMA is only 15 km, it will be an impressive astrometric instrument, comparable to cm-wave VLBI arrays, because of the tenuous and stable troposphere at the Atacama site. The expected astrometric accuracy will be < 0.1 milliarcsec. The high frequency capabilities of ALMA will open up astrometry to an order of magnitude more stellar objects than are now available with cm-wave arrays. Three major astrometric endeavors are: (1) the motion of objects in the solar system; (2) the position and motion of stars in the Milky Way galaxy; (3) the fundametal celestial inertial reference frame, defined by the distant quasars. The astrophysical goals of potential ALMA astrometric observations will be described.

102 Using fast-switching data to characterize atmospheric phase fluctuations at the Sub-millimeter Array

Dharam Vir Lal (Institute of Astronomy & Astrophysics, Academia Sinica), ,
Satoki Matsushita (Institute of Astronomy) & Astrophysics, Academia Sinica), , Jeremy Lim (Institute of Astronomy & Astrophysics, Academia Sinica)

For the sub-millimeter and millimeter band observations, we have been routinely adopting the secondary calibration cycle time of 20-30 minutes, which is the same as any typical centimeter band observations. This cycle time, largely corrects only the instrumental phase fluctuations and there exists residual phase fluctuations, which are attributed to temporal and spatial atmospheric phase fluctuations. Hence, the classical calibration cycle needs closer attention for any future sub-millimeter/millimeter band observations. We have therefore obtained fast-switching test data, cycling between three nearby calibrators, using Sub-millimeter Array (SMA) with a cycle time of $\sim$90 seconds, in order to understand and optimize the calibration cycle suitably, thereby to achieve the projected sensitivity, angular resolution and dynamic range for the SMA. We will present the preliminary results obtained (above the Mauna Kea) from this study and compare them with the fast-switching results obtained at centimeter bands with the Very Large Array.

103 Complementary EVLA/ALMA Science in the Next Decade

James S. Ulvestad, NRAO

The Expanded VLA (EVLA) will be coming on line with its new correlator in 2010, and have complete 1-50 GHz frequency coverage by the end of 2012. Together, EVLA and ALMA will have nearly complete frequency coverage from 1 GHz to 1 THz, at resolutions ranging from subarcsecond to many arcseconds; more than half the sky will be visible by both telescopes at elevations above 30 degrees. For high-redshift star-forming galaxies, EVLA will detect and image lower order CO transitions while ALMA does the same for higher order transitions; the two telescopes also will make complementary imaging observations of synchrotron radiation, free-free emission, and dust emission from distant galaxies. This paper will present this and other examples of complementary EVLA/ALMA science that will be available in the next decade.

104 ALMA: Fourier phase analysis made possible

François Levrier, Ecole Normale Supérieure

Fourier phases contain a vast amount of information about structure in direct space, that most statistical tools never tap into. We address ALMA's ability to detect and recover this information, using the probability distribution function of phase increments, and the related concepts of phase entropy and phase structure quantity. We show that ALMA is definitely needed to achieve significant detection of phase structure, and that it will do so even in the presence of a fair amount of atmospheric phase fluctuations. We also show that ALMA should be able to recover the actual "amount" of phase structure in the noise-free case, if multiple configurations are used.

105 Testing the Prototype ALMA Water Vapour Radiometers at the SMA

Michael Reid,
Alison Peck, Richard Hills, Ross Williamson, John Richer, Scott Paine

The ALMA design specifications call for water vapour monitors (WVRs) to be used to measure and correct for atmospheric phase variations. Since December, 2005, two prototype ALMA WVRs have been installed at the Submillimeter Array (SMA) on Mauna Kea in Hawaii. We report here on the results of simultaneous observations using the WVRs and the SMA receivers, showing that the WVRs accurately track the phase variations seen by the interferometer. These results bode very well for the prospects of phase-correcting ALMA data using WVRs.

106 NANTEN2: A Submillimeter Telescope for Large Scale Surveys at Atacama

Toshikazu Onishi, Nagoya University,
Norikazu Mizuno, Nagoya University, Akira Mizuno, Nagoya University, Yasuo Fukui, Nagoya University, NANTEN2 team

We have been installing the 4-m telescope, NANTEN2, at Pampa la Bola at an altitude of 4,800m to realize a large-scale survey at submm wavelengths. This is an upgrade of the 4-m mm telescope, NANTEN, that was operated at Las Campanas observatory, Chile. We have been carrying out extensive molecular cloud surveys in the Galaxy as well as toward the Magellanic system for seven years. In this new NANTEN2 project, we will make large-scale surveys in a 100-800 GHz range toward the Galaxy and the nearby galaxies including the Magellanic Clouds by using mainly CO and CI lines. The purpose is an elucidation of evolution of interstellar matter and the mechanism of star-formation in the Local Group by revealing the distribution, kinematics, and physical conditions of interstellar gas in the atomic-molecular phases with the thorough extensive survey. The telescope is enclosed in a dome with a shiftable membrane to prevent perturbations such as strong wind and sunlight. The installation started at the beginning of 2004. The first wave at 115GHz was observed in September, 2005, and the first sub-mm wave both at 460GHz and 806GHz was successfully obtained in May, 2006. The highest observing frequencies will be covered by the KOSMA SMART receiver, a dual-frequency array receiver operating between 492 and 809 GHz, and array AOS as backends. This project is in collaboration between universities in Japan (Nagoya University and Osaka Prefecture University), in Germany (University of Cologne and University of Bonn), in South Korea (Seoul National University), and in Chile (University of Chile).

107 **Improving Image Fidelity: Techniques and Calibrations**

Stuartt Corder, California Institute of Technology,
Melvyn Wright, Radio Astronomy Lab, University of California Berkeley

Given the large dish size and short observing wavelengths of ALMA, a large fraction of science targets will require mosaiced observations. While mosaicing provides a variety of benefits, the need for accurate image representation, or high image fidelity, drives a number of concerns. Efforts are underway at the Combined Array for Research in Millimeter Astronomy (CARMA) to improve and optimize image fidelity in wide-fields with this heterogeneous array. CARMA, which consists of 6-10.4 m, 9-6.1 m, and, eventually, 8-3.5 m telescopes, provides an excellent testbed for new calibration techniques. We present simulations, calibrations, and observing techniques that are currently being developed at CARMA to improve image fidelity. Techniques for improving pointing by using offset optical pointing are discussed and the benefits and improvement over traditional radio pointing are explored. Low resolution holography is utilized to provide better estimates of primary beam shape and side lobe pattern for individual telescopes as a function of various observing conditions. These primary beam shapes can be used in the deconvolution of mosaiced images. The side lobe pattern of the larger dishes is measured so that eventual illumination by 3.5 m dishes provides stable estimates of the side-lobe contribution allowing the inclusion of 10.4 x 3.5 m dish baselines. We conclude with examples of the use of these techniques on real sources and provide estimates of the fidelity improvement over standard techniques.

108 **Calibration Strategies for the ALMA Compact Array (ACA)**

Baltasar Vila Vilaro, NAOJ,
Shigehisa Takakuwa, NAOJ, Daisuke Iono, NAOJ, Yohiharu Asaki, ISAS, Ryohei Kawabe, NAOJ, Keiichi Asada, NAOJ

ALMA will demand "relative" and "absolute" amplitude calibration accuracies unprecedented in the mm and sub-mm ranges. This requires obtaining very high-quality calibration data at a large range of spatial and temporal scales. The Science Team of the Atacama Compact Array (ACA), one of the ALMA-J contributions to the Enhanced ALMA and in charge of providing the zero-spacing and short-baseline data, has been developing/simulating several possible strategies for the ACA data calibration that can achieve the expected calibration requirements. We will present here the main results of all these studies (so far and currently in progress).

109 CONDOR - A Heterodyne Receiver at 1.25 - 1.5 THz

M. C. Wiedner, Universitaet zu Koeln,
G. Wieching, M. Emprechtinger, U. U. Graf, C. E. Honingh, K. Jacobs, K. Rettenbacher, N. H. Volgenau

The CO N^+ Deuterium Observations Receiver (CONDOR) is a heterodyne receiver that operates between 1250–1530GHz. Its primary goal is to observe star-forming regions in CO, N^+, and H_2D^+ emission. The instrument follows the standard heterodyne design. It uses a solid state local oscillator (LO), whose signal is overlaid with that of the sky using a Martin-Puplett interferometer. The heart of the receiver is a superconducting NbTiN hot electron bolometer (HEB). The bolometer has an area of $0.25 \times 2.8\mu$m and is mounted on a SiN membrane in a waveguide mixer block. To facilitate operation at remote sites, CONDOR is the first receiver that cools the HEB with a closed-cycle system. Since HEBs are particularly sensitive to temperature fluctuations as well as modulations in LO power, we use a Pulse Tube Cooler, which has less vibration than, e.g., a Gifford-McMahon cooler. In order to further minimize vibrations and temperature fluctuations, the mixer and first amplifier are mounted on a separate plate connected via flexible heat straps to the 4 K stage. CONDOR has an intermediate frequency (IF) of about 1.0-1.8 GHz. We consistently obtain receiver noise temperatures below 1800 K and minima in the spectral Allan variances at 25-35 s, which is approximately the optimum individual on-source integration time. In November 2005, CONDOR was successfully commissioned on the 12 m Atacama Pathfinder EXperiment (APEX) telescope. Pointing observations were performed on the Moon and Mars. The first spectral line observations were obtained of CO J=13-12 emission at 1497 GHz from several sources in Orion.

110 Inner Dust disks of MWC480 and LkCa15: a 50 AU cavity around LkCa15

Anne Dutrey, L3AB,
Vincent Piétu, IRAM, Séphane Guilloteau, L3AB, Edwige Chapillon, IRAM, Jerome Pety, IRAM

To constrain the dust distribution and its properties in inner proto-planetary disks, we performed sub-arcsecond high-sensitivity interferometric observations of the thermal dust emission at 1.4mm and 2.8mm in the disks surrounding LkCa 15 and MWC 480, with the 800 m baselines of the IRAM PdBI array. This provides an angular resolution of ~ 50 AU at the Taurus distance. These new observations bring very important constrains in inner dust disks. In particular, we report the existence of an inner cavity of ~ 50 AU radius in the inner disk of LkCa 15. We present and discuss in the poster the main results of the analysis.

111 Chemistry in Disks: Deep search for N_2H^+ in the protoplanetary disks around LkCa15, MWC480 and DM Tau

Anne Dutrey, L3AB,
Thomas Henning, MPIA, Stéphane Guilloteau, L3AB, Dmitry Semenov, MPIA, Vincent Piétu, IRAM, Katharina Schreyer, Jena University , Aurore Bacmann, L3AB, Ralf Launhardt, MPIA, Jerôme Pety, IRAM

We present new high-sensitivity interferometric observations of N_2H^+ in three protoplanetary disks surrounding DM Tau, LkCa 15 and MWC 480. The observations were obtained with the IRAM array. We report two detections for LkCa 15 and DM Tau and an upper limit for MWC 480. In this poster, we describe the data analysis and discuss these new results using existing HCO^+ column densities. We also compare the observations to a steady-state disk model with vertical temperature gradient coupled to gas-grain chemistry.

112 Evidence for molecular outflow-ambient interfaces in CepA-East?

C. Codella, INAF, IRA, Firenze, Italy,
S. Viti, UCL, London, UK, D.A. Williams, UCL, London, UK, R. Bachiller, OAN, IGN, Spain

We present observations of the CepA-East star forming region and describe an extended and dynamically distinct feature not previously recognised. This feature is present in emission from H_2CS, OCS, CH_3OH, and HDO at –5.5 km s^{-1}, but is not traced by other conventional tracers of star forming regions such as CS, SO, H_2S, and SO_2. The feature is extended up to at least 0.1 pc. We show that the feature is neither a hot core nor a shocked outflow. However, the chemistry of the feature is consistent with predictions of a model of an eroding interface between a fast wind and a dense core; mixing between the two media occurs in the interface on a timescale of 10-50 years. If these observations are confirmed by detailed maps and by detections in species also predicted to be abundant this feature would be the first detection of such an interface in regions of massive star formation. An important implication of the model is that a significant reservoir of sulfur in grain mantles is required to be in the form of OCS.

113 The molecular jet driving the HH212 protostellar outflow

C. Codella, INAF, IRA, Firenze,
S. Cabrit, Observatoire de Paris, F. Gueth, IRAM, Grenoble, F. Bacciotti, INAF, OAA, Firenze, R. Cesaroni, INAF, OAA, Firenze, B. Lefloch, LAOG, Grenoble, D. Panoglou, CAUP, P. Garcia, CAUP, M.J. McCaughrean, U. Exeter

We present interferometric mm-wavelengths observations of the 2-1 and 5-4 thermal lines of SiO towards the young bipolar HH212 outflow located in the Orion molecular cloud. The new extended configuration of the Plateau de Bure IRAM interferometer allowed us to attain resolutions of about 0.3 arcsec at 1.3 mm. We find that the SiO emission is confined in two highly collimated bipolar jets, located along the main axis of the outflow. In addition, continuum observations at 1.3 mm clearly identify the driving source. The red- and blue-shifted lobes consist of two highly symmetric pairs of bullets suggesting that episodic mass loss has occurred. The jet kinematics and the comparison of the results with theoretical models are discussed.

114 The APEX Survey of Southern High Mass Star Forming Regions

Carolin Hieret, MPIfR,
Silvia Leurini, MPIfR, Karl Menten, MPIfR, Peter Schilke, MPIfR, Friedrich Wyrowski, MPIfR

A very important phase in the early stages of high mass star formation is the hot molecular cores phase. It is characterized by a very complex chemistry in the hot and dense gas that can be observed in a multitude of rich spectra, which in turn allows determination of the physical and chemical properties of these massive star forming cores. With new instruments opening up the (sub)mm sky from vantage positions in the southern hemisphere (APEX, ATCA; ALMA in the future), we now can study these objects in the most obscure, earliest stages of their existence. We have started to investigate with APEX a large sample of more than 100 sources south of 20 degrees, based on IRAS colour selection criteria, choosing sources already observed in 1.2 mm continuum emission by. Systematically studying such a large sample of sources, covering a wide range in distances, masses and luminosities, is a fast and efficient way of obtaining a good overview of the different stages of high-mass star formation from the onset of hot molecular cores to the formation of UCHIIs and in addition it is a great preparation of target sources for high resolution studies with ALMA. Our APEX results already show a promising selection of sources, some of them very molecular line rich. Amongst many other things, we find signs of clustered star formation and evidence for outflows. The sources have, with varying degrees of completeness, already been mapped and observed in a variety of lines. In the future we shall attempt to study them as completely as possible. I will present the APEX survey and highlight the most important results obtained so far.

115 Observations of water masers at AU-scale in the NGC1333-IRAS4 region

J.F. Desmurs, Observatorio Astronómico Nacional (OAN), Madrid, Spain,
C. Codella, Osservatorio Astrofisico di Arcetri, Firenze, Italy, J. Santiago, OAN, M. Tafalla, OAN

We conducted a study of water masers around the Class 0 protostars called A, B, and C in the NGC1333-IRAS4 region. Using the VLBA, we observed water emission at milliarcsecond scale and in phase referencing over four epochs spaced one month to measure proper motions. Our observations confirmed the high variability of H_2O maser emission, shorter than one month. The high angular resolution has allowed us to show that A2, the weakest source of the IRAS4A binary system, is associated with water masers. On the other hand, the spots associated with IRAS4B show a high degree of collimation and they are probably tracing the protostellar jet producing the bipolar molecular outflow.

116 Creation and Destruction: the impact of massive star formation on the interstellar medium across the Hubble sequence

Elias Brinks, University of Hertfordshire, UK,
Ioannis Bagetakos, University of Hertfordshire, UK, Fabian Walter, MPIA, Heidelberg, Germany

The formation of massive stars, usually in (super) star clusters, their rapid evolution and subsequent demise as supernovae has a major impact on their immediate surroundings. The combined effect of stellar winds and supernovae, going off within rapid succession and within a small volume, creates expanding bubbles of coronal gas within the neutral interstellar medium (ISM) in spiral and (dwarf) irregular galaxies. These expanding shells in turn sweep up and compress neutral gas which can lead to molecular cloud formation and the onset of secondary or induced star formation. We present an inventory of shell structures in a sample of nearby (3 Mpc < D < 10 Mpc) galaxies across the Hubble sequence, taken from The HI Nearby Galaxy Survey (THINGS) in order to quantify the feedback of massive star formation on the ISM. Maps of the neutral atomic gas at 7" angular and 5 km/s velocity resolution will be compared with maps of similar resolution at other wavelengths made available by the Spitzer IR Nearby Galaxy Survey (SINGS). We will determine the 2D and 3D porosity of the ISM and probe which are the sufficient and necessary conditions for gas in these expanding shells to turn molecular and subsequently form next generations of stars. Our datasets will be invaluable in identifying those regions which will be most promising to follow up with ALMA.

117 Depletion and the Evolution of High Mass Protostellar Objects

Gary Fuller, University of Manchester,
Holly Thomas, University of Manchester,

The results of a survey of the rare isotopologues $C^{17}O$ and $C^{18}O$ towards candidate high mass protostellar objects are presented and used to investigate the possibility of identifying evolutionary trends in the process of massive star formation. Comparison of the column density of CO derived from these observations and that derived from submillimetre continuum observations, show a range of degrees of depletion of CO towards the objects. A result which is confirmed by detailed radiative transfer modelling of the expected line emission from a selection of the sources which span the range of source properties. The presence of depletion towards these objects shows that the gas in these regions remains cold and dense for $\sim 2-4\times10^5$ years. A comparison of the linewidths of $C^{17}O$ and previously published observations of CS is used to separate the sample into two groups. The larger linewidth, $\Delta v > 3$km s^{-1}, objects, MC1 sources, are shown to have the lowest $C^{17}O$ abundances. They also show evidence of heating by the central young star, have steep density profiles and high mass to luminosity ratios. The remaining sources, MC2/3 sources, show less evidence of heating, have shallower density profiles and smaller M/L ratios. The connection between properties of the cores ($C^{17}O$ abundance, density profile) and stellar heating suggests an intimate connection between the cores and the objects they are forming. It is proposed that the identified groups represent an evolutionary sequence in the properties of these massive cores.

118 Exploring southern star forming regions : H2 jets driven by very young protostars

Teresa Giannini, INAF-OAR,
Massimo De Luca, INAF-OAR, Dario Lorenzetti, INAF-OAR, Brunella Nisini. INAF-OAR

We have performed a systematic search for H2 jets emission associated with 1.2 mm dust peaks found in the Vela Molecular Ridge (VMR)-D. We have found evidence of shocked emission in a dozen out of 19 imaged fields, and six of them show a clear jet-like morphology. A comparison with K, N and MSX images has given negative results as regards as the identification of possible driving sources of these jets, but a clear association is found with IRAS 60,100 μm and 1.2 mm dust peaks. In this poster we will present an analysis of the discovered jets along with the implications derived on the nature and evolutive stage of their exciting sources.

119 Molecular Emission as a Test for the Early Stages of Massive Star Formation

Guillem Anglada, IAA-CSIC, Spain,
Mayra Osorio, IAA-CSIC, Spain, Susana Lizano, CRyA-UNAM, Mexico, Paola D'Alessio, CRyA-UNAM, Mexico

We present a model aimed to reproduce the high angular resolution observations of the early stages of massive star formation. We compare the model predictions with the results of the observations of several ammonia transitions of the G31.41+0.31 hot molecular core reported in the literature. As a result, we obtain a self-consistent description of the physical conditions in the core, as well as of the distribution of the molecular ammonia abundance. In particular, the model reproduces succesfully the spatial distribution of the ammonia (4,4) main line and satellite emission as observed with the VLA with an angular resolution of 0.6 arcsec. These observations represent the highest angular resolution molecular line images toward a hot molecular core published to date. This kind of modelling is necessary to properly account for the high angular resolution molecular line data that ALMA will provide.

120 Studying stellar ejecta with ALMA

Grazia Umana, INAF OACt,
Corrado Trigilio, INAF-OACt, Carla Buemi, INAF-OACt, Paolo Leto, INAF-IRA, Luciano Cerrigone, Catania University, Patrizia Manzitto, Catania University

Studying Stellar Ejecta with ALMA Late stages of stellar evolution are often characterized by strong instabilities, whose signpost is the formation of circumstellar envelopes (CSEs). The formation of such structures can take place more or less quietly, in the form of large, prolonged mass-loss or in the form of explosive events. The importance of studying these evolutionary phases resides in the fact that stars that go through these phases play a prominent role in the Galactic evolution: through their stellar ejecta, they contribute to the chemical enrichment of ISM and are important sources of UV radiation and kinetic energy for the ISM. We will exploit the possibilities that ALMA will offer to study such ejecta. We will focus in particular on the stellar ejecta around YPNs and LBVs. Broad similarities between observed bipolar morphology in both kind of objects have raised the question whether a similar shaping agent exists. The high angular resolution and sensitivity of ALMA would allow to map the emitting components coexisting in the nebulae i.e. ionized/neutral gas and dust, providing important constraints on mass-loss and shaping processes which leads to the formation of such ejecta.

121 YSO outflows and their influence on the star formation process

Hector G. Arce, American Museum of Natural History

Outflows from young stellar objects originate very close to the forming star, and thus they must interact with the infalling envelope surrounding the protostar and disk. Since circumstellar envelopes are the main mass reservoir of low-mass protostar, outflow-induced perturbations must have a significant effect on the final mass of the nascent star. Circumstellar envelopes have sizes in the order of 1000 AU or less, corresponding to less than 10" in the nearest star-forming regions. Detailed studies of the impact of outflows on the envelope and the infalling gas therefore require high spatial resolution millimeter interferometer observations. Moreover, the combination of infall and outflow motions, rotation, and turbulence, in the presence of steep density gradients on very small scales, in turn demands both high spectral resolution and observations of a number of molecular species which trace different density and kinematic regimes. ALMA's capabilities will allow us to conduct multi-molecular line mapping of the gaseous surroundings of many young stars at very high angular (and velocity) resolution, thereby allowing us to study in great detail the outflow launching mechanism, the entrainment process, and the interaction between the outflow and the environment very close to the protostar (i.e., the infalling envelope, and protoplanetary disk) where outflows presumably have the most impact on the mass-assembling process. We present current studies on these topics and how ALMA will greatly improve our understanding of YSO outflows and their influence on the star formation process.

122 Physical modeling of the massive protostellar object IRAS18151-1208 : first step before HSO and ALMA

Herpin Fabrice, L3AB, Observatoire de Bordeaux,
Marseille Matthieu, L3AB, Observatoire de Bordeaux, Bontemps Sylvain, L3AB, Observatoire de Bordeaux, Wyrowski Friedrich, MPI-Bonn, van der Tak Floris, SRON-Groningen

The Bordeaux Observatory participates to the HSO/HIFI-Guaranteed Time Water Key Program (van Dishoeck et al.) and is in charge of the sub-program toward the IR-quiet massive protostars. Since water is one of the main coolant for the inner regions of the collapsing envelopes of protostars, it is a critical tracer of the physics in these regions. Before ALMA provides us with a sufficient spatial resolution to resolve the individual sources, this program will improve our knowledge of the earliest phases of the formation of high-mass stars. In order to fully interpret the Herschel observations and to prepare future ALMA observations, it is however of vital importance to build good physical (density and temperature distributions) models from ground-based observations of the objects. Our first results for one of our target, IRAS18151-1208, are presented here. The IRAS 18151-1208 region was chosen because it contains three different massive protostellar objects, very likely at three different stages of evolution. Main physical characteristics and simple model of these sources can be derived and directly discussed in an evolutionary scheme.We use the spectral energy distribution (SED) to derive density and temperature law, using both an ad-hoc gas distribution and the DUSTY software. We describe them with a 1D multi-shell model which can be treated with RATRAN. The derived line profiles are directly compared with our recent observations (30m and MOPRA). We finally discuss the obtained constrains for the sources, and also the limitations of our modeling in the context of the preparation of the Herschel program.

123 High velocity SiO emission in the protostellar jets imaged with the Submillimeter Array (SMA)

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Chin-Fei Lee, Harvard-Smithonian Center for Astrophysics, U.S.A., Sheng-yuan Liu, ASIAA, Hsien Shang, ASIAA

We present the high-resolution (1″–2″) SiO J=5–4 and/or J=8–7 images of the highly-collimated protostellar outflows driven by the nearby low-mass protostars observed with the Submmillimeter Array (SMA). The SiO emission in the HH211, HH212, and L1448-mm outflows comes from the central narrow jets with extremely high-velocity (EHV) along the outflow axes. These three SiO jets share the common morphological and kinematical properties; the jets consist of chains of knots, the innermost pairs of knots are located at $\pm$1″–2″ from the central stars, and the radial velocities of the SiO emission reach close to the terminal velocities of the entire jets at the positions of the innermost knots. In all three cases, the innermost pairs of knots are prominent in the higher-J transition, suggesting that the temperature and density of the gas in the knots at the base of jets are higher than those in the downstream. It is likely that the innermost knots in these outflows are closely related to the primary jets immediately after being launched from the protostar/disk systems. A comparison between the SiO jet from HH211 and that from L1448-mm suggests that the density of the EHV jet in the L1448-mm outflow is lower than that in the HH211 outflow. Since the L1448-mm outflow is likely to be more evolved than the HH211 outflow, the difference between two might be related to the evolution of the EHV jet.

124 Protostellar outflows imaged with the Submillimeter Array

Naomi Hirano, ASIAA,
Chin-Fei Lee, Harvard-Smithsonian CfA, Sheng-Yuan Liu, ASIAA, Hsien Shang, ASIAA, and SMA Team,

The high velocity emission of the high excitation lines in the submillimeter waveband traces warm and dense component of molecular outflows. The high angular resolution of (sub) arcsecond provided by the submillimeter array (SMA) allows us to study the spatial and kinematical properties of the dense and warm outflowing gas in the close vicinity of its driving source. We will summarize the recent results of the molecular outflows from protostellar sources traced mainly by the SiO and CO emission lines, and discuss the morphological and kinematical structure of extremely high velocity component seen in the youngest protostars, evolution of outflows, and possible driving and collimation mechanism of outflows.

125 Deducing the link between 6.7 GHz methanol masers and massive star formation

Jagadheep D. Pandian, Cornell University

It is well established that molecular masers are an excellent probe of early stages of star formation. Class II methanol masers are particularly interesting since they have not yet been observed in regions other than those associated with high-mass star formation. The 6.7 GHz methanol maser is the strongest of Class II methanol masers, and is thus an excellent tool to detect and study high-mass star forming regions. It is however unclear as to which evolutionary phases of massive stars are associated with 6.7 GHz methanol maser emission. High resolution millimeter and submillimeter observations are required to resolve this issue. In this paper, we present results from the Arecibo Methanol Maser Galactic Plane survey, and discuss the impact of upcoming instruments like ALMA on deducing the link between 6.7 GHz methanol masers and massive star formation.

126 Chemical Evolution of Young Bipolar–Molecular Outflows in Low–mass Protostars

Joaquín Santiago-García, Observatorio Astronómico Nacional (OAN),
Mario Tafalla, Observatorio Astronómico Nacional (OAN), Rafael Bachiller, Observatorio Astronómico Nacional (OAN)

We have carried out a chemical survey of bipolar outflows from low-mass protostars with the aim of studying their evolution and the evolution of their driving young stellar objects (YSOs). Key molecular species such as CO, SiO, H_2CO and CH_3OH have been observed toward selected positions (mainly along the shocks) of 17 Class 0 and Class I YSOs of low luminosities ($L<25\ L_\odot$) with the IRAM 30-m telescope. We have developed an homogeneous method to estimate the molecular abundances, with particular attention to determine accurate upper limits in the cases of non-detections. Our preliminary analysis confirms that outflows powered by Class 0 sources constitute a rather inhomogeneous group, in particular because they exhibit different chemical behaviours, with strong enhancements of some molecular species in their shocks, a fact not observed in Class I outflows. From a careful analysis and comparation based on the definition of two ”chemical velocity ranges”, we find a systematic behaviour of the chemistry depending on the line profile shapes. Within a given particular outflow, such variations are very likely the result of the chemical evolution processes. Thus, it appears that the chemical differences from outflow to outflow can be interpreted as a result of the strongly time-dependent shock chemistry, so one can use the chemical composition as a kind of clock–tracer to study the outflow evolution. The peculiarities of the chemical behaviour are then used to produce a rough classification of the outflows and to suggest a time evolutionary sequence. Such time sequence could be usefull to eventually refine the classification of Class 0 protostars.

127 Extremelly Collimated Outflow in Taurus

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Mario Tafalla, Observatorio Astronomico Nacional (OAN), Dough Johnstone, Herzberg Institute of Astrophysics., Rafael Bachiller, Observatorio Astronomico Nacional (OAN)*

We present the first case of a highly collimated, extremely high velocity bipolar outflow in Taurus. It is powered by the low-luminosity (0.4 $L_{\odot}$) source IRAS 04166+2706 and contains gas accelerated up to 50 km s^{-1} with respect to the ambient cloud both toward the blue and the red (uncorrected for projection). At the highest velocities, the outflow collimation factor exceeds 20, and the gas displays a very high degree of spatial symmetry. This very fast gas presents multiple maxima, and most likely arises from the acceleration of ambient material by a time-variable jet-like stellar wind. When scaled for luminosity, the outflow parameters of IRAS 04166 are comparable to those of other extremely high velocity outflows like L1448, indicating that even the very quiescent star-formation mode of Taurus can produce objects powering very high energy flows ($L_{mec}/L_{*} > 0.15$). Thanks to its proximity to us ($\sim$ 140 pc), work in progress with high resolution maps from PdBI interferometer shows that I04166 exhibits the best example to date of a dual jet/cavity geometry. Low velocity V-shaped emission in CO with straight line walls appears simultaneously with high velocity CO and SiO emission in a jet like structure exactly at the centre of the cavity, making I04166 a perfect test for combined wind and jet launching models of bipolar molecular outflows.

128 Probing the Inner 200 AU of Low-Mass Protostars with the Submillimeter Array

*Jes K. Jørgensen, Harvard-Smithsonian CfA,
Tyler Bourke, Harvard-Smithsonian CfA, James Di Francesco, Herzberg Inst. of Astrophysics, Chin-Fei Lee, Harvard-Smithsonian CfA, Philip C. Myers, Harvard-Smithsonian CfA, Nagayoshi Ohashi, ASIAA*

In the earliest stages of the evolution of low-mass young stellar objects, the central star and disk are deeply embedded in a large envelope of gas and dust. Submillimeter interferometric observations are excellent for studies of these earliest embedded stages: the high angular resolution resolve the innermost regions of the protostellar envelopes and even the circumstellar disks. The high excitation transitions of many common molecular species at submillimeter wavelengths likewise probe warm and dense gas in the envelopes. We here present some of the results from a large survey of a sample of deeply embedded low-mass protostars (Class 0 objects) with the Submillimeter Array. In total nine different sources have been observed in a wide variety of lines of common molecular species together with continuum. The observations are interpreted on basis of detailed dust and line radiative transfer models. The continuum observations resolve the innermost regions of the protostellar envelopes and place strong constraints on the presence and properties of their circumstellar disks. The line observations reveal the complex structure of these sources, for example, the chemical and dynamical variations throughout the envelopes and the importance of the outflows on both.

129 Low Mass Star Formation: Recent Results from the Submillimeter Array

Jes Jørgensen, Harvard-Smithsonian CfA,
Tyler Bourke, Harvard-Smithsonian CfA, and SMA Team

In the earliest stages of the evolution low-mass young stellar objects, the central star and disk are deeply embedded in a large envelope of gas and dust. The Submillimeter Array (SMA) is excellent for studies of these earliest embedded stages: the high angular resolution resolve the innermost regions of these envelopes and even the circumstellar disks. The high excitation transitions of many common molecular species in the submillimeter likewise probe warm and dense gas in the envelope and thereby constrain the dynamics and chemistry in the innermost ($<$ 200 AU) regions of protostellar cores. We here present an overview of results from SMA programs studying the deeply embedded stages of low-mass protostars.

130 Challenges to detect the Magnetic activity of YSO outflow by ALMA

Hideyuki Kamaya, Kyoto University,
Ryohei Suzaki, Kazunari Shibata

The YSO out flow is possible to be triggered by the magnetic tension and pressure of and around the YSO disk. Unfortunately, however, there are few observational evidences of the importance of the magnetic field. Then, in my talk, we propose some observational strategies to detect the activity of the magnetic field by using ALMA. In our consideration, the plasmoid from the disk-stellar system has important roll and we examine its detection by ALMA. Furthermore, the distribution of the magnetic field should be examined. We will present qualitative estimation to detect the Zeemann effect along the out flow.

131 Hydrogen recombination lines in the millimeter as a potential SFR indicator

Kaustuv Basu, MPIfR Bonn,
Karl Menten, MPIfR Bonn, Frank Bertoldi, University of Bonn

We expect to present the first results of a currently ongoing project, with the data from IRAM Plateu de Bure interferometer as obtained during the summer 2006, to demonstrate the prospect of using mm-wavelength hydrogen recombination lines as a new high-mass star-formation rate indicator in the luminous starburst galaxies. We give the theoretical motivations for using the mm-wave lines for this purpose: absence of dust extinction, optically thin line emission, and low stimulated emission even in the highly overdense regions. The later two reasons make it particularly advantageous to use the mm-lines as compared to the cm-lines. The expected line fluxes are of the order of few mJy for the nearby starburst galaxies, so present instruments limit the usefulness of this method mostly to the local universe, but the hope is that this new technique will become an extremely useful tool also at high redshifts once ALMA comes online.

132 The Nature of Low-Mass Class I sources: from JCMT and APEX to ALMA

T.A. van Kempen (Leiden Observatory),
E.F. van Dishoeck, D. Salter, M.R. Hogerheijde, J.K. Jørgensen, F. Schöier, A. Crapsi, R. Güsten, P. Schilke

During the Class I phase of star-formation a protostar transits from an embedded source with large amounts of envelope material to a classical T Tauri star, where a disk surrounds the protostar. In practice it has been difficult to determine their physical and chemical characteristics.In addition to confusion from its surroundings, Class I sources are not dominated by a particular component: all play important roles in the analysis of Class I sources. Careful examination of both continuum and spectral lines is necessary to identify 'contaminators' in the form of edge-on disks or low-mass Class 0's. Here we present the results of a study of 32 Class I YSO's in Ophiuchus, Chamaeleon and Corona Australis, all easily accessible to ALMA. JCMT and APEX observations have been used to study these objects with high frequency lines. Lines from HCO+ 4-3 probe the high density ($> 10^6$ cm^{-3}) gas whereas high-J CO 4-3 and 7-6 (+ isotopes) uniquely trace the warm ($>$50 K) gas close to the YSO. The line shapes can be used to separate various components (e.g. the inner warm quiescent envelope and outflow material). Initial results suggest a strong constraint on the total amount of warm material traced by the CO 7-6 line (van Kempen et al, 2006, A&A) . Outflow material at larger scales is proposed to explain ISO-LWS observations. Such in-depth descriptions of the physical structure around Class I sources are essential for chemical analysis such as needed with H_2O with Herschel-HIFI. Future ALMA Band 9 observations are crucial to probe the inner warm region of YSOs on subarcsec ($<$100 AU) scales.

133 Combining S-D and Interferometric Data to Image Protostellar Cores

Yasutaka Kurono, The Univ. of Tokyo

We have performed combined imaging with the Nobeyama 45m Telescope and the Nobeyama Millimeter Array(NMA). We will present the detailed combining processes including how to convert the single-dish image data to the spatial frequency components, viewpoints that should be noted and how these results give scientific impacts. Our studies should be a basis of imaging methods which will be adopted for the ACA system to fill in the short-spacing information. These results are very attractive in the meaning of suggesting the possibility of the scientific programs when using the ALMA array with the ACA system. The data we combined are $H^{13}CO^{+}(J = 1-0)$ line data toward protostellar cores and envelopes whose evolutional stage is very early, and in which very young(Class 0 phase) low-mass single stars and binary stars are forming. Although most stars form as a binary system or multiple system, it is necessary not only to understand the evolution of the density and velocity structures from protostellar cores which form single stars, but to clarify the relation and the difference between the single and binary-system formation for a more comprehensive understanding of star forming process. To achieve this purpose, it is essential to quantify physical properties such as the angular momentum distribution inside the protostellar cores over a wide spatial range from the center part ($\sim$1,000AU) to the outside region ($\sim$10,000AU) with high resolution. Therefore, it is a very suitable method for this research, to unite the interferometric data and SD data, and then make imaging with the complete spatial components.

134 Molecular Outflows in the R Coronae Australis Region

Lewis B.G. Knee, Herzberg Institute of Astrophysics

The Corona Australis molecular cloud is a nearby complex in which star formation is concentrated towards the cloud core associated with the young Herbig Ae star R CrA. There is a lack of large scale and high angular resolution observations of molecular outflows in this area, and so the number of outflows in this region and the identity of the sources driving them are unknown. Here, I report preliminary results of two large scale CO surveys of the R CrA region performed with the SEST and the JCMT.

135 Tracing Hidden Compact Outflows in the OMC1 South Region

Luis Zapata, MPIfR,
Paul Ho, CfA & ASIAA, Luis F. Rodriguez, CRyA-UNAM

We present high angular resolution ($2.'8 \times 1.'7$) SiO J=5→4; $v = 0$ line observations of the OMC1S region in the Orion Nebula made using the Submillimeter Array (SMA). We detect for the first time a cluster of four compact bipolar and monopolar outflows that appear to be energized by millimeter and infrared sources associated with this region. The SiO molecular outflows are compact (< 3500 AU), and show a broad range of velocities. Based on recent high angular resolution observations of this molecule toward other outflows, we propose that the SiO thermal emission is tracing may be the youngest and most highly excited parts of the outflows which cannot be detected by other molecules. Moreover, since the ambient cloud is weak in the SiO line emission, these observations can reveal flows that in other molecular transitions will be confused with the ambient velocity cloud emission. Analysis of their positional-velocity diagrams show that some components of these outflows may be driven by wide-angle winds very close to the exciting object.

136 A Mid-Infrared Spitzer Study of the Herbig Be star R Mon and the associated HH 39 knots

Marc Audard, Columbia University,
Stephen Skinner, University of Colorado, Manuel Güdel, Paul Scherrer Institut, Thierry Lanz, University of Maryland, Frits Paerels, Columbia University, Hector Arce, American Museum of Natural History

We report on initial results of our Spitzer Cycle 2 program to observe the young massive star R Mon and its associated HH 39 knots in the mid-infrared. Our program used all instruments on-board Spitzer to obtain deep images with IRAC of the HH 39 complex and of R Mon and its surroundings, a deep image of HH 39 at 24 and 70 microns with MIPS, and mid-infrared spectra with the SH, LH, and LL modules of the IRS. The aim of this program is to study the physical links in a young massive star between accretion disk, outflows and jets, and shocks in the associated HH object. Our preliminary analysis reveals that knots C, D, and G of HH 39 are clearly detected in most IRAC bands. In IRAC4 (8 microns), diffuse emission, probably from PAHs, appears as foreground emission covering the HH39 emission. The HH39 knots are barely detected at 24 microns, but again dust continuum emission covers the knots and shows the same structure as observed with IRAC at 8 microns. A preliminary analysis of the IRS spectra does not show evidence of line or continuum emission. Further analysis is, however, required due to the faintness of the Herbig-Haro knots. Finally, we obtained the SH and MIPS SED spectra of R Mon. Its strong mid-infrared spectrum does not show evidence of strong emission lines on top of its continuum; a detailed analysis may detect any faint emission in the SH spectrum. The combined IRAC, IRS, and MIPS data of the R Mon/HH 39 system will help us to understand circumstellar disk processing, and the connection between jets, outflows, and HH objects.

137 Young Southern Massive Star Forming Regions in the Mid-IR

Diego Mardones, Universidad de Chile,
Esteban Morales, Universidad de Chile, Kate Brooks, ATNF, Guido Garay, Universidad de Chile

We present mid-IR imaging and spectroscopic observations of 12 southern young massive star forming regions, with the TIMMI2 camera on the ESO 3.6 m telescope. ATCA radio continuum and SIMBA 1.2-mm continuum data of these sources were recently submitted for publication. The mid-infrared images reveal single extended sources towards 9 regions, two are double and only one region shows multiple sources. The morphology of the extended emission matches that of the radio continuum well, suggesting that the emission comes mainly from warm dust near the ionized gas. The mid-ir luminosity of the sources fall in the $10-100 L_{\odot}$ range, and the sizes of the emitting regions fall in the $\sim 0.05-0.5$ pc range, consistent with arising from UCHII regions. We used the public SPITZER-GLIMPSE data to determine accurate astrometry of our images, and found that the mid-ir and ATCA emission are shifted typically by $1.5''$, indicating that dust and ionized gas don't coexist. The N-band spectra exhibit in all sources a prominent silicate feature ($\sim$ 9.7 μm) in absorption, [Ne II] line emission in 7 sources, and PAH at 11.3 μm in only one region. From the silicate feature we estimate column densities in the range $2-10\times10^{22}$ cm^{-2}, which are consistent (within a factor of ~ 2) with those estimated from the 1.2-mm data. These regions will be important targets for studies of massive star formation with ALMA. In this poster we present the images and spectra, discuss about the nature of the sources observed, comparing the mid-IR emission with other wavelength data.

138 The Kinematics of Massive Star-Forming Cores

Michael A. Reid, Harvard-Smithsonian Submillimeter Array,
Brenda Matthews, Lori Allen, Luis Chavarria

We present BIMA and preliminary SMA observations of the spatially-resolved kinematics of massive star-forming cores in two massive star-forming regions. Spatially-resolved kinematic data are essential to differentiate between competing models of massive star formation. Because massive star-forming molecular cloud cores are typically quite distant, few present instruments offer the spatial resolution and sensitivity necessary to determine their kinematic structures. This is an area in which ALMA will excel. Our BIMA and SMA observations focus on a small sample of relatively nearby massive pre- and proto-stellar cores in NGC 7538 and IRAS 23033+5951 which we have observed in up to seven different molecular lines. Our sample includes several candidates for rotating massive cores which may be capable of forming individual massive stars by monolithic collapse and disk accretion.

(139) ASTE observations of circumstellar material around nearby pre-main sequence stars

Munetake Momose, Ibaraki University,
Takashi Tsukagoshi, NRO, NAOJ, Ryohei Kawabe, NAOJ, Tomohiko Sekiguchi, NAOJ, Yoshimi Kitamura, ISAS/JAXA, Seiichi Sakamoto, NAOJ, Masao Saito, NAOJ

We report the results of CO($J = 3-2$) observations toward 14 classical T Tauri stars in Taurus molecular cloud using the ASTE telescope. The sample is almost identical to that of the NMA survey obsevations of continuum emission at $\lambda = 2$ mm. Spectra toward four adjacent points 20″ apart along the RA or Dec axis from each star were also obtained to discriminate the gaseous components directly associated with the central star from ambient cloud components. The integrated intensity of the enhanced emission toward the star shows fairly good correlation with the H_α luminosity, which is a good measure of accretion activity of circumstellar disk. This suggests the amount of dense circumstellar material in the cetral regions within 20″, or 2800 AU from the central star, decreases as the disk accretion activity diminishes.

(140) Infall and the formation of a massive star

Maria T. Beltran, Universitat de Barcelona ,
Riccardo Cesaroni, Osservatorio Astrofisico di Arcetri, Claudio Codella, Istituto di Radioastronomia, INAF, Leonardo Testi, Osservatorio Astrofisico di Arcetri, Ray S. Furuya, Subaru Telescope, Luca Olmi

We present evidence of infall in a circumstellar rotating toroid enshrouding a luminous star in the massive star-forming region G24.78+0.08. Besides being one of the rare direct detections of infall in a young high-mass star, our finding stands unique for the simultaneous presence of three elements in the same massive object: a rotating, collapsing toroid, a bipolar outflow, ejected along the rotation axis, and a hypercompact ionized (HII) region. The large accretion rate and the existence of a hypercompact HII region confirm that the accretion cannot be spherically symmetric and must occur in a circumstellar disk.

141 The blue lobe of the L1157 outflow at high spatial resolution

Milena Benedettini, INAF-IFSI,
Serena Viti, University College London, Rafael Bachiller , Observatorio Astronómico Nacional - IGN, Frederic Gueth, Institut de Radio Astronomie Millimetrique, Claudio Codella, INAF - Istituto di Radioastronomia

We present high spatial resolution maps, obtained with the Plateau de Bure Interferometer, of the blue lobe of the chemically active L1157 outflow. We observed simultaneously 4 lines at 3mm, namely OCS(7-6), HCN(1-0), CH_3OH (2_K-1_K) and HC_3N (11-10). Moreover, the bright B1 clump has also been observed at better spatial resolution ($3.1 \times 2.8''$) in CS (2-1), ^{34}SO (3_2-2_1) and CH_3OH (2_1-1_1). These high spatial resolution observations show a very rich structure in all the tracers, revealing a clumpy structure of the gas. In fact, the three clumps (B0, B1 and B2) detected by the previous IRAM 30-m single dish observations have been resolved in more sub-clumps. In particular, near B0 we detected two new clumps one in the south-west position and one located between B0 and B1. The B1 clump results formed by four sub-clumps in an arch-shape position and the B2 clumps is composed by two sub-clumps. A new clump is detected between B1 and B2. The two southern sub-clumps (B2) appear similar both in the line intensity and the elongated shape while the B0 and B1 sub-clumps have a circular shape with size of 10-15 arcsec and they have different lines intensity suggesting a gradient of the physical conditions at small scale. We also present the results from a chemical model aimed to explain the behaviour of the abundances of the most prominent molecular species in this prototypical chemically rich outflow.

142 High-Mass Star Formation: Comparison between millimeter observations the NGC 2264-C protocluster and SPH simulations of a collapsing clump

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Patrick Hennebelle, LRA/ENS Paris, France, Philippe André, SAp/CEA Saclay, France

NGC 2264-C is a massive (M=1600 $M_\odot$) star-forming clump (D=0.8pc) located in the Monoceros molecular cloud (d=800pc). Based on miilimeter observations and radiative transfer calculations Peretto et al. (2006) proposed that this clump is currently forming a high-mass star in its center. The proposed scenario for high-mass star formation is based on the formation of an ultra-dense core through the coalescence of several Class 0 cores, this coalescence process being driven by the fast global collapse of the parent clump. The extreme pressure an density reached in this central ultra-dense core allows the formation of a high-mass star. In order to confirm the physical validity of this scenario we performed hydrodynamical simulations (SPH) of a gravitationally unstable ellipsoidal clump of 1000 $M_\odot$. We also initially added turbulent velocity fluctuations. The goal was to find a simulation which matches all the observational constraints we have on NGC2264-C (i.e previous IRAM 30m and new PdBI observations). Through a wide set of different initial conditions we found one simulation in which a series of time step, once convolved to the resolution of our observations, reproduces quite remarkably these observations. Confirming the scenario proposed by Peretto et al. (2006), we also put severe constraints on the initial conditions of the collapse of NGC 2264-C. Finding wether this scenario is general to high-mass star formation could be one important task for ALMA.

143 Characterizing the relationship between outflow and collapse for High-Mass Protostellar Candidates

Nicolas Peretto, University of Manchester, UK,
Gary Fuller, University of Manchester, UK, Holly Thomas, University of Manchester, UK

If it is clear that high-mass stars form in massive dense cores, it is however still unclear how these massive dense cores form and what are the processes which convert the molecular material of the parent core into a (proto-)star of 10Msol or more. To start to address these issues a spectral survey was recently completed to observe HCO^+ and H_2CO towards a sample high mass protostellar candidates. This survey demonstrated that towards these objects there is a statistical excess of blue-asymmetry line profiles consistent with the presence of infall (Fuller et al. 2005). On the basis of multiple blue-asymmetric spectral lines observed towards each source, 21 sources were identified as good candidates for the presence of infall. Follow-up mapping observations of a sample of these candidates have recently been obtained in, e.g. CO(3-2), HCN(4-3) and HCO^+(1-0), using the JCMT and IRAM 30m telescopes. We will present the results of these mapping observations and their analysis. We will discuss the implications concerning the evolution of massive dense cores, focussing on the relation between outflow and collapse. We will also suggest how ALMA will in the future contribute to the study of these aspects of high-mass star formation.

144 Probing the excitation conditions of molecular bullets associated with Class 0 outflows through multi-frequency SiO observations

Brunella Nisini, INAF-OAR,
Claudio Codella, INAF-IRA, Teresa Giannini, INAF-OAR, Joaquin Santiago Garcia, OAN-IGN, John Richer, MRAO, Rafael Bachiller, OAN-IGN, Mario Tafalla, OAN-IGN

We have performed a SiO multiline analysis (from J=2-1 to J=11-10) of the molecular bullets along the Class 0 outflows L1448-mm and L1157-mm, obtained through observations with IRAM and JCMT. Such analysis have been performed to investigate the physical properties of different types of bullets, in order to explore their excitation conditions and give constraints on their formation and evolution. We have computed the main physical parameters, finding that the bullets close to L1448-mm, which are associated with gas at very high speed, have higher excitation conditions ($n \sim 10^6$ cm^{-3}, T $\gtrsim$500 K) with respect to the L1157 bullets ($n \sim$2 10^5 cm^{-3}, $T \sim 200 - 300$ K). In both the sources, is evidenced the presence of velocity components at different excitation conditions, with the denser and/or warmer gas associated with the gas at the higher speed. However, while the bulk of the emission in L1448 is contributed by the high-excitation gas, in L1157 most of the emission comes from the low excitation gas at ambient velocity. The overall observations support the idea that the L1157 clumps represent shock interaction events older than for the L1448 bullets. In these latters, the velocity structure and the variations of physical parameters with the velocity resemble very closely those found in ClassI/II small scale optical/IR jets, suggesting that the SiO emission could directly trace the primary jet from the Class 0 sources. ALMA will provide the way to test this hypothesis through sub-arcsec observations of these jets close to the embedded protostars, allowing us to probe the jets origin in these very young objects.

145 Millimeter Interferometry Observations of the Disks around Pre-Main Sequence Stars

J. Patience, Caltech,
J. Koda, Caltech, R. Akeson, E. Jensen , A. Sargent, Caltech

With the OVRO array we mapped the dust emission from Class I and Class II binary systems in Ophiuchus and Taurus to measure the distribution and evolution of cool outer dust in young binaries. The 3mm continuum data spatially resolve the pairs. The viability of planet formation in the disks encircling the primary and secondary depends upon factors such as the disk mass and lifetime. In Ophiuchus the dust emission is dominated by the primary disk for both the Class I and II systems, and the primary disks have masses comparable to the Minimum Mass Solar Nebula, while the secondary disk lifetimes may compromise future planet formation. In contrast the Taurus Class I maps show detections of each component, indicating longer secondary disk lifetimes. With the CARMA array we also observed a Taurus member with a spectral type at the boundary of stars and brown dwarfs to investigate the disk around a low mass object. Analysis of the 3mm data and previous measurements at shorter wavelengths suggests a large disk size. With the resolution and sensitivity of the ALMA array it will be possible to extend these studies to closer multiple systems and lower mass objects.

146 Massive Star Formation: Recent Results from the Submillimeter Array

Qizhou Zhang, Harvard-Smithsonian CfA,
Sheng-Yuan Liu, ASIAA, and SMA Team

The Submillimeter Array (SMA) is an ideal facility to study the warm, dense dust and gas surrounding massive young stars, through (sub)arcsecond resolution observations of continuum and molecular line emission over a 2x2 GHz bandwidth. We will summarize recent results on massive star formation obtained with the SMA. Topics include charactization of deeply embedded protoclusters, evidence for disks around massive young stars, the morphologies and kinematics of energetic bipolar outflows, and the complex chemistry of "hot core" regions.

147 IRAS 20343+4129: star formation in a closely packed environment

Robert Estalella, Universitat de Barcelona,
Aina Palau, Universitat de Barcelona, Paul T. P. Ho, Harvard-Smithsonian Center for Astrophysics, Henrik Beuther, Harvard-Smithsonian Center for Astrophysics

IRAS 20343+4129 is a massive protostar candidate, at a distance of 1.4 kpc, displaying strong dust and CO emission from single-dish observations. Two IR sources lie inside the IRAS ellipsoid error: IRS 1 and IRS 3. We carried out 1.3 mm continuum and CO (2-1) observations with the SMA. A high-velocity bipolar outflow in the EW direction is detected clearly associated with IRS 1, the most embedded source in the region. Weak dust continuum emission is found toward IRS 1, with a mass of 0.2–0.5 $M_{\odot}$. These results suggest that IRS 1 is not a high-mass YSO, but an intermediate Class I source. The strongest dust condensations are associated with low-velocity extended gas and H_2 emission features at both sides of IRS 3. This suggests that dust is associated with the walls of an expanding cavity which could be produced by a stellar wind from IRS 3, or driven radiatively if we assume that IRS 3 is a B2 star. Globally, we found objects with different evolutionary stages that have been born in the same parental cloud. Their distribution seems to be determined by the cloud initial conditions and with triggering by a shock front driven by IRS 3.

148 Infrared study of the southern Galactic star forming region IRAS 14416-5937

Sarita Vig, TIFR, India; INAF-OAA, Italy

This star forming region has been mapped simultaneously in two far infrared bands at $\sim$ 150 & 210 μm using the TIFR 1-m balloon borne telescope with $\sim 1'$ angular resolution. Spatial distribution of the temperature of cool dust and optical depth at 200 μm have been obtained taking advantage of the similar beams in the two TIFR bands. This region comprises of two sources designated as A and B, separated by $\sim$ 2 pc.We have used the 2MASS JHK$_s$ bands as well as the GLIMPSE-Spitzer data of this region to study the stellar populations of the embedded young cluster. From the near and mid infrared images, we identified a dust lane due north-west direction of the source A. The spatial distribution of young stellar objects in and around the dust lane suggests that active star formation is taking place along the dust lane and is possibly triggered by the expanding HII regions of A and B.

149 Hot cores in the submm - obscured by dust?

Peter Schilke, MPIfR,
Claudia Comito, MPIfR, Carolin Hieret, MPIfR, Friedrich Wyrowski, MPIfR, Rainer Rolffs, MPIfR

Hot cores have large column densities, so large that the dust opacity becomes larger than unity in the submillimeter range. Assuming spherical geometry, that would mean that the centers are obscured above a certain frequency range, and studies of these regions are not possible in the submillimeter range any more, which would be bad news for ALMA and especially HIFI. To investigate this problem, we performed observations of HCN(9-8) at 796 GHz with the APEX telescope, aiming at detecting the vibrationally satellite line, which is pumped by 14 μm IR photons and therefore guaranteed to be emitted from the vicinity of the powering source. In this poster, we present the results and a preliminary analysis.

150 Search for HCO^+, CS, HCN, C_2H and CH_3OH in a disk around AB Aur

Katharina Schreyer, Astrophysikalisches Institut und Universitäts-Sternwarte,
Stéphane Guilloteau, L3AB, Observatoire de Bordeaux, Dmitry Semenov, Max Planck Institute fuer Radioastronomy, Heidelberg

We performed observations of HCO+, CS, C_2H, HCN, & CH_3OH using the IRAM Plateau de Bure Interferometer aimed at determining the chemical composition in the circumstellar disk around the Herbig Ae star AB Aurigae. Using previously derived disk parameters, e.g., the orientation, inclination, geometry, etc, we estimate the resulting molecular column densities and the fractional abundances (partly as upper limits) of the observed species by applying both the χ^2-minimization technique and a steady-state disk model with vertical temperature gradient coupled to a stochastic gas-grain chemical network. The obtained abundances are more than one order of magnitude lower than the typical values for low-mass star-forming cores and resemble those in the T Tauri disks.

151 Multiline (sub)millimeter observations of the high-mass proto cluster IRAS 05358+3543

Silvia Leurini, Max Planck Institut fuer Radioastronomie, European Southern Observatory

IRAS 05358+3543 (d$\sim$1.8 kpc) shows intense high mass star formation activity; Beuther et al.(2002) found at least three highly-collimated outflows, the most prominent of which is more than a parsec in length and massive (M$>$ 10 M$_\odot$). Class II CH_3OH (Minier et al. 2000) and H_2O (Tofani et al. 1995) are also detected. Here we present an interferometric analysis of the region at mm (PdBI) and submm (SMA) wavelengths in molecular lines. At our resolution, the previously known three millimeter dust condensations split up in several other condensations, whose masses, column densities and visual extinction were derived by analysing the continuum data. The main dust condensation shows several indicators of hot core, with the detection of several complex molecules and very excited transitions. A preliminary analysis on CH_3OH and CH_3CN indicates high temperature (240 K) and density (5×10^7 cm^{-3}) in the gas surrounding the core; CH_3OH abundance is typical of a hot core. The line profiles show two velocity components, which, despite the high resolution of our data ($\sim$ 1"), may indicate still unresolved structure. The physical conditions of the gas surrounding the protostars and the chemical differentiation of the different dust condensations will be discussed.

152 Flares in binary system as seen by ALMA

Simona Toscano, Univ. Catania, Italy,
Corrado Trigilio, INAF-OACt, Grazia Umana, INAF-OACt, Carla Buemi, INAF-OACt, Paolo Leto, INAF-IRA Noto

The flaring behavior of RS CVn binaries has been studied extensively at centimeter wavelenghts, but very little has been done concerning flares in the millimeter regime, where the nonthermal gyrosynchrotron emission is much more likely to be optically thin. An active period on the binary system HR1099 has been followed by using the Noto Single Dish radiotelescope (at 5 GHz) and VLBA (at 8.4 GHz). On the basis of these observations, we developped an evolutive model for the flare that allowed us which foresee how ALMA can be used to study such kind of events.

153 **Profiling Young Massive Stars**

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Michael G. Burton, University NSW, Australia, Maria R. Cunningham, University NSW, Australia,
V. Minier, DAPNIA/CEA Saclay, France

We have drawn spectral energy distribution (SED) diagrams for 162 of the 405 sources reported in our SIMBA survey (Hill et al, *MNRAS* 2005, **363**, 405). The fits reveal six parameters; the luminosity, mass, temperature, H_2 number density, the surface density and the luminosity-to-mass ratio. Including sources sizes and distances from our earlier work, eight parameters are known. Analysis reveals a clear temperature and luminosity distinction amongst the four classes of source. Intriguingly, the mm-only cores (without methanol maser & UC HII) are of comparable mass to sources with a methanol association, whilst collectively these two classes are slightly less massive than cores with UC HII. The mm-only core are smaller, less luminous, and cooler than the other sources, with at least 45% devoid of midinfrared MSX emission. This has led us to propose that the mm-only cores are a precursor to the methanol maser in the formation of massive stars. The mm-only cores comprise two distinct populations distinguished by temperature. The cool-mm are distinctly different from the warm-mm and those sources with methanol masers and UC HII regions. The cool-mm sources have smaller radii, are less luminous with lower luminosity-to-mass ratios, and are more dense, with higher H_2 number and surface densities. The warm-mm sources on the otherhand display similar characteristics to sources with a methanol maser and/or radio continuum source. These results suggest that the warm-mm cores are the precursors to the methanol maser sources, whilst the cool-mm sources are examples of failed cores (Vazquez-Semadeni et al., *ApJ* 2005, **618**, 344).

154 **Identifying compact groups of high mass protostars**

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Future submillimeter interferometry has the potential to resolve many of our questions on the formation of massive stars in clusters. The popular phenomenon of mass segregation in optical and near-infrared star clusters has been taken as indirect evidence that massive stars preferentially form in the center of clusters. A more direct test of this hypothesis can be made via a high-resolution (<1000 A.U., $< 0.5''$ at 2kpc) millimeter continuum imaging of massive dust cores, both with and without accompanying infrared clusters. These observations will reveal compact groups of deeply-embedded stars and protostars not yet visible in the mid-infrared (Hunter et al. 2006, ApJ 649, 888). Our present knowledge at these scales is mostly limited to non-thermal maser lines. But once ALMA begins to deliver thermal dust continuum images and spectral line images with angular resolution approaching that of VLA water maser images, a wonderful synergy will result. First of all, we will finally be sensitive to high protostellar densities, sufficient (10^6 pc^{-3}) to directly test predictions of the merger hypothesis of massive star formation. Second, we may learn how to distinguish between maser emission that traces circumstellar material vs. that which traces outflows, thereby increasing the value of archival maser data. As an initial demonstration of this approach, SMA 1.3mm images of nearby young massive star-forming regions will be shown along with VLA water maser positions. Even with the modest sensitivity and dynamic range of the SMA images, millimeter multiplicity has been detected and the dust cores often show a good correlation with the maser positions.

155 AFGL 2591: a massive circumstellar disk of dust and water

Floris van der Tak, National Institute for space Research (SRON),
Malcolm Walmsley, Osservatorio di Arcetri, Fabrice Herpin, Observatoire de Bordeaux, Cecilia Ceccarelli, Observatoire de Grenoble

High-mass stars may form by disk accretion like low-mass stars, but evidence for massive accretion disks remains sparse. We present IRAM PdB observations of 1.3 mm dust continuum and $H_2^{18}O$ line emission that reveal a rotating disk around the nearby (d=1 kpc) luminous ($2 \times 10^4 L_\odot$) protostar AFGL 2591.

156 Imaging the sub-arcsec environment around high-mass protostars - Future studies in the Southern Hemisphere

Vincent Minier, CEA Saclay, France

In the preparation of an ALMA, APEX and VLT/VISIR project to study high-mass protostellar environment, we are selecting a sample of Southern sources at distances < 5 kpc and declination < 20 deg. The targets are selected based on their overall dust emission morphology (protoclusters, hot cores, dark clouds), methanol maser and IR emission properties. We present the overall project as well as a recent study of high-mass protostellar objects at very high angular resolution. This study combines methanol maser and thermal mid-IR continuum observations in search for protostellar disk and outflow signatures. Complementary spectral line observations with IRAM-PdBI, ATCA and Mopra/ATNF are and will be available. Future surveys in the Southern Hemisphere are also presented including planned surveys with the ArTeMiS 4000-pixel bolometer arrays.

157 CONDOR Observations of High Mass Star Formation in Orion

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CONDOR, the CO, N^+, Deuterium Observations Receiver, is designed to make velocity-resolved observations of the CO, [NII], and p-H_2D^+ lines in the 1.35 and 1.5 THz atmospheric windows. CONDOR's first light observations were made with the APEX telescope in November 2005. The CONDOR beam on APEX (at 1.5 THz) was expected to consist of a 4.3″main beam and a 73″error beam; this beam structure was verified from scans of Mars. The pointing accuracy, also determined from Mars scans, was better than 7-arcsecond. The average atmospheric transmission during our Orion observations (el=57 deg) was $19 \pm / - 4\%$ along the line-of-sight. A forward efficiency of F=0.8 was determined from sky dips, and observations of the Moon and Mars were used to couple the CONDOR beam to sources of different sizes ($\eta_c = 0.40$ and 0.10, respectively). With CONDOR, we observed CO $J = 13 - 12$ emission from three sites of high-mass star formation in Orion (IRc2, FIR4, and NGC2024). In our analysis of IRc2, we assume that all spectra from positions < +-20-arcseconds include a "spike" (width= 5 km s-1) and a "hot core" component (width=35 km s^{-1}). The optically thin spike emission arises from the interface of the Orion Ridge and the energizing M42 HII region. A simple isothermal model fit to the J=13-12 and higher-J CO lines reveals that the layer must indeed be warm ($T_k in = 620K$), dense ($n(H_2) = 2\,10^6$ cm$^-$3), and thin ($N(CO) = 1.2\,10^{16}$ cm^{-2}). Because the Ridge has a temperature gradient, we are currently modeling the data using a PDR code. We are also analyzing the line wings to constrain the outflow properties.

158 Cold CO Gas in Protoplanetary Disks

Yuri Aikawa, Kobe University

In a disk around DM Tau, previous observation of ^{13}CO ($J = 2 - 1$ and $1 - 0$ transitions) derived the CO gas temperature of $\sim 13 - 20$K, which is lower than the sublimation temperature of CO. We argue that the existence of such cold CO can be explained by a vertical mixing of disk material. As the gas is transported from a warm layer to a cold layer, CO is depleted onto dust grains with a timescale of $\sim 10^3$ yr. Because of the steep temperature gradient in the vertical direction, an observable amount of CO is still in the gas phase when the fluid parcel reaches the layer of ~ 13 K. Such cold CO is more abundant in disks with larger diffusion efficiency and larger grain size.

159 On how ALMA can help in the study of the planet-debris disk connection

Amaya Moro-Martin, Princeton University

Using data from the Spitzer Legacy Program FEPS, we have searched for debris disks around 9 FGK stars (2-10 Gyr) known from RV studies to have one or more massive planets. Only HD 38529 is found to have an excess emission above the stellar photosphere with a SNR at 70mum of 5.4. Applying K-S and survival tests to the FEPS sample and the published FGK GTO results, we find that there is no significant correlation between the presence of IR excess and the presence of planets. This may indicate that planetary systems with Plutons and smaller planetesimals producing debris dust may be more common than planetary systems harboring gas giant planets. However, even with its enormous gain in sensitivity, Spitzer is not able to detect Solar System-like dust disks around any but the very nearest stars. The unprecedented sensitivity provided by ALMA will be able to contributed significantly in this regard. ALMA will also allow us to study individual debris disks in greater detail. We illustrate this point with HD 38529, a solar-type star (4.78 Gyr) with two close-in planets and a Kuiper Belt. We can constrain the location of the 70mum-emitting dust from the modeling of its SED, giving some insights on how the the planets may have carved the dust disk. However, we show that the SED models are degenerated. Spatially resolved observations with ALMA will be able to break this degeneracy. In addition, sensitive (sub)millimeter detections are needed to put constraints on the dust mass, a significant fraction of which could be locked in grains >1 mm that emit efficiently in the (sub)millimeter but contribute little to the infrared emission observed by Spitzer.

160 Are truncated stellar disks linked to the molecular gas density?

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Viviana Casasola,University of Padova, Francoise Combes, LERMA, Paris, Giuseppe Galletta, University of Padova, Michael Pohlen, Kapteyn Institut,Groningen

Previous studies suggest a correspondence between star formation and a threshold value in the local molecular mass, sometimes coupled with dynamical constraints. If such a threshold persists for sufficient time, it should introduce the visible turnover or truncation of the observed stellar luminosity profile. To test this point here we present mapping of the molecular hydrogen distribution in two disk galaxies, one with and one without a truncation in their radial stellar light distribution. The galaxies have been observed with IRAM 30m telescope. Preliminary results are discussed.

161 High-resolution observations of dense gas in the L1489 IRS protoplanetary disc

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Recent observations of HCO+ and continuum emission from the L1489 IRS protoplanetary disc done with the Sub-milimeter Array (SMA) show the existance of a keplerian disc embedded in a flattened circumstellar structure with a radius of 2000 AU. These data are used, together with near- and mid-infrared observations from HST/NICMOS and Spitzer/IRS, to model the SED over a wide spectral range. Predicted ALMA observations of this disc is also presented and compared with the SMA data.

162 Resolving the disk of TW Hya with the SMA

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David Wilner, Harvard-Smithsonian CfA, Paul Ho, Harvard-Smithsonian CfA, ASIAA, Tyler Bourke, Harvard-Smithsonian CfA, Yuri Aikawa, Kobe Univ., Geoffrey Blake, Caltech, Nuria Calvet, U. Michigan, Edwin Bergin

We present Submillimeter Array (SMA) observations of TW Hya with $1''$ to $3''$ resolution in lines of ^{12}CO, ^{13}CO, $C^{18}O$, HCO^+, HCN and CN, as well as DCN and DCO^+ – the first resolved images of deuterated species in a protoplanetary disk. We use an irradiated accretion disk model and two-dimensional radiative transfer calculations to fit the visibility data for various basic disk parameters, including the outer radius R_{out}, inclination angle i, $(\mathrm{vsini})_{100AU}$ and the fractional abundances of various molecules. We find that the intensities of the CO J=2–1, 3–2, and 6–5 lines require substantial CO depletion, as well as higher gas temperatures than dust temperatures near the disk surface, perhaps due to X-ray heating. We derive a DCO^+/HCO^+ ratio of 0.045 ± 0.020 and a DCN/HCN ratio of 0.047 ± 0.015 averaged over the disk, consistent with previous single dish observations. However, we find from the resolved data that the DCO^+/CO ratio appears to increase by an order of magnitude from the inner disk (R$<$20 AU) to the outer disk (R$>$80 AU). This trend is consistent with chemical models, which predict higher deuterium fractionation in the outer disk where low temperature and high CO depletion prevail. With the SMA, we are starting to constrain the thermal, physical and chemical structure of the TW Hya disk as a function of radius and height, but the inner disk properties (R$<$20 AU) remain elusive due to limited sensitivity and angular resolution. These inner regions, where planets are thought to form, will be accessible with ALMA.

163 Protoplanetary Disks: Recent Results from the Submillimeter Array

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David Wilner, Harvard-Smithsonian CfA, Nagayoshi Ohashi, ASIAA, Sean Andrews, U. Hawaii IfA , and SMA Team,

High spatial and spectral resolution make the Submillimeter Array (SMA) an ideal instrument for the study of the physical and chemical structure of protoplaneary environments. We present the results of recent (sub)arcsecond continuum and multiple molecular lines observations of protoplanetary disks to examine the kinematics, temperature and density profiles of the gas and dust surrounding the young stars.

164 Circumstellar Disks in Young Clusters: OVRO Continuum Survey of NGC 2024, ONC, and IC 348

John Carpenter, Caltech,
Josh Eisner, UC Berkeley

Measuring the properties and lifetime of circumstellar accretion disks around young stars place important constraints on the planet formation process. We have used the OVRO millimeter-wave interferometer to obtain 2-5 arcsec resolution, 3 mm continuum mosaics of the young clusters NGC 2024, the Orion Nebula Cluster, and IC 348. Each mosaic encompasses between 100 and 300 low mass stars and provides a snapshot of disk properties in time. The results indicate that the average solar-type star at an age of 0.3 - 1 Myr has a disk mass comparable to that of the solar system and have the raw materials to form planetary systems comparable to our solar system. By a stellar age of about 2-3 Myr, no massive disks are detected, suggesting the formation of massive planets of several Jupiter masses is already at an advanced stage, or such massive planets are rare.

165 Resolving Structure in Transition Disks around Young Stars

Meredith Hughes, Harvard-Smithsonian CfA;,
David Wilner, Harvard-Smithsonian CfA

The evolution of protoplanetary disks will be a major topic for ALMA, which will image emission from dust and trace molecules with unprecedented sensitivity and resolution. We are using millimeter interferometry to make pathfinding high resolution observations of nearby, gas-rich "transition" disks whose spectral energy distributions suggest the presence of large central holes, features that may be linked to giant planets in formation. We present new subarcsecond resolution VLA 7 millimeter observations of the TW Hya disk that provide direct evidence for clearing of dust in the inner region. We also present SMA and IRAM PdBI observations of the GM Aur disk that resolve dust and gas emission on a range of size scales, including the clearing of dust in the inner region. We use CO J=3-2 data, together with a physical model derived from fitting the spectral energy distribution and non-LTE radiative transfer, to constrain basic parameters of the outer disk.

166 13CO/C18O J=2-1 SMA observations of the disk around young star HD169142

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We present SMA observations of ^{13}CO and C^{18}O J=2–1 line emission of the disk around the pre-main-sequence A5 star HD169142 (d=145 pc). The disk is resolved at a $1\farcs4$ resolution. Together with previously published 12CO 2-1 imaging, our data reveal the Keplerian velocity field in this disk seen at low inclination. The ^{13}CO emission extends to 275 AU from the star. We adopt a disk model whose physical structure is consistent with the broad-band spectral energy distribution. We then calculate the molecular excitation and line formation of the observed transitions. The data is well matched by the model which assumes $M_\star$=2 $M_\odot$, M_{disk}=0.02 $M_\odot$, R_{out}=235 AU, i=13° and a depletion factor of 4 for both ^{13}CO and C^{18}O. After identifying the physical regions in the disk where the emission comes from, we conclude that this model accurately describes the disk's structure at all vertical heights and thus presents a good starting point for interpretation of future ALMA observations of molecular line emission from this disk.

167 The role of turbulent mixing in chemical evolution of protoplanetary disks

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Dmitry Wiebe, Institute of Astronomy of RAS, Moscow, Thomas Henning, Max Planck Institute for Astronomy, Heidelberg,

Transport processes play crucial role in the global evolution of protoplanetary disks. Likely, they are responsible for the presence of crystalline silicate dust in outer disk regions (e.g., van Boekel et al. 2005) and in comets and meteoritic bodies in our solar system (e.g., Wooden et al. 2005), and non-thermal broadening of the observed molecular lines (e.g., Dartois et al. 2003). However, the influence of transport phenomena on the chemical evolution of protoplanetary disks has hardly been studied in detail. In my poster, I will show the importance of turbulent diffusion for disk chemical evolution. Briefly, the time-dependent chemistry over 5 Myr is modeled, using a T Tau disk structure with vertical temperature gradient, a gas-grain chemical network with stochastic surface chemistry, and several chemical models with and without turbulent mixing included. Overall, the turbulent diffusion in both radial and vertical directions does not affect significantly the abundances of many simple molecules and ions produced by fast photoreactions in the disk, but is very important for more complex molecules and deuterated species whose evolution is governed by surface chemistry. Particularly, it is demonstrated that the 2D mixing modeling results can explain the puzzling "CO depletion problem"—a large amount of CO gas at $T<15$ K observed in the DM Tau disk (Dartois et al. 2003).

168 Reliability of the disk chemical modeling

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We study how uncertainties of the rate coefficients of chemical reactions in the UMIST 95 database affect the modelled molecular abundances in a protoplanetary disk around a low-mass star. For that, we randomly varied the gas-phase reaction rates within their uncertainty limits and calculated sets of time-dependent abundances in several representative disk locations, using a gas-grain chemical model supplied with a set of surface reactions. All species are separated in different groups according to the sensitivity of their final abundances to the rate uncertainties. We found that such division depends on the disk location, since distinct processes control the chemical evolution of various disk regions. Typically, the modelled abundances of simple species are imprecise up to a half order of magnitude, and in general increase with the number of atoms in the molecule. We apply a straightforward sensitivity method introduced in [1] to analyze the correlations between the time-dependent abundances and varied rate values in order to identify those reactions whose rate uncertainties affect the resulting concentrations of the pre-selected, observationally important species to the largest extent. It is demonstrated that the rate coefficients of only a handful of chemical reactions need to be determined more accurately in order to improve significantly the reliability of disk astrochemical models, which might be a task for future laboratory studies and theoretical investigations.
References 1. A.I. Vasyunin et al., Astron. Lett. vol. 30, pp. 566-576 (2004) 2. V. Wakelam et al., A&A vol. 444 issue 3, pp. 883-891 (2005) 3. V. Wakelam et al., A&A, in press

169 Molecular line radiative transfer in protoplanetary disks: Monte Carlo versus approximate methods

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We report on the benchmarking of several approximate multi-dimensional line radiative transfer methods and the exact Accelerated Monte Carlo approach, using a simple model of a young low-mass protoplanetary disk with constant molecular abundances. The readily observable CO, $C^{18}O$, HCO^+, and DCO^+ molecules are chosen to represent four distinct cases of the molecular emission generation in the disks, namely, high/low optical depth line excited at high/low critical density. We find that accuracy of the molecular level populations computed even with the simplest LTE approach is good everywhere through the disk for those molecules that are excited at low critical density, e.g. CO and its isotopes. This is in contrast to HCO^+ and DCO^+ whose transitions are not thermalized in a substantial part of the disk and thus require more sophisticated approximate methods for accurate modeling of the radiative transfer. We present such a 1D-method “2ray” and discuss its algorithm in detail. Also, several modifications to the canonical Monte Carlo formalism are proposed, which allows to speed up the line radiative transfer modeling in protoplanetary disks by a factor of 10–50. Finally, we compare the resulting spectral line images of the disk obtained with approximate and exact methods in detail.

170 A keplerian gaseous disk around the B0 star R Mon

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We present high angular resolution observations of the ^{12}CO 1→0 (beam= $2.3'' \times 1.3''$) and 2→1 (beam= $1.5'' \times 0.9''$) rotational lines. At these scales ($1''$ is $\sim$ 800 AU at the distance of R Mon) the high velocity CO emission has two components: the high velocity gas flowing outwards the star along twisted filaments located in the walls of the cavity and the circumstellar disk. We have used a flat disk model to fit the ^{12}CO 1→0 and 2→1 emission in a strip perpendicular to the outflow axis and to determine the kinematics of the gaseous disk. The model assumes standard ^{12}CO abundance (X(CO)=8 10^{-5}), radial dependent temperature and density laws ($T_k = 4500 * r(AU)^{-\alpha}$, $n \propto r^{-\beta}$) and Local Themodinamic Equilibrium. The CO emission is consistent with a flat disk at an inclination angle of $20 \pm 5^\circ$ in *keplerian rotation* around the star. The disk is fitted with a mass of 0.014 $M_\odot$, an outer radius of 1500 AU, and values of $\alpha = 0.65$ and $\beta = 1.3$ for the indexes of the temperature and density laws. In addition, we present new continuum observations of the region with a beam$\approx 0.72'' \times 0.33''$. These observations provide more accurate estimates of the position and size of the dusty disk which are now settled to RA(2000): 06:39:09.96, DEC(2000): 08:44:09.55, and $r_{out} \lesssim$150 UA.

171 Thermal Continuum Observations of TNOs & Debris Disks

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Trans-Neptunian Objects (TNOs) are observable Kuiper Belt Objects, and they are believed to be remnants of planetesimals which was formed at the early stage of formation of our planetary system. On the other hand, debris disks should be extra solar Kuiper Belts, and they are thought to be composed of the fragment-dusts of planetesimals in the extra planetary systems. Due to their faintness, their physical properties are poorly known currently, although they can bring a direct clue of the formation of the planetary systems. In this talk, we propose thermal continuum observations of the TNOs and the debris disks. Flux measurements of the TNOs which are apparently small ($\sim 10^{-2}{}''$), cold ($\sim 30 - 50$K) and detectable in sub-mm, allow us determinations of the effective diameters and albedos of planetesimals using high sensitivity tool for sub-mm wavelength such as the combined ALMA. Continuum mappings of the debris disks give us to obtain the total mass of planetesimals disk and the extents of planetesimal regions ($\sim 10''$.) with high fidelity tool for extended sources such as ACA. This study can make us link between observation and theory on formation of our/extra solar systems.

172 Multiple-Sized Dust Grains in Planetary Resonances in Debris Disks

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We present submm images of debris disks in Vega, Fomalhaut, Beta Pictoris, and Epsilon Eridani obtained using the SHARC II at CSO. In Vega our 350 and 450 micron images show inhomogeneous dust ring structure characterized by three evenly-spaced peaks, quite different to the highly asymmetric morphology seen at 850 micron. We attribute this morphological difference to the existence of different grain populations, with the 350 micron emission being due to grains of size ~ 1 mm and the 850 micron to much larger grains (~ 1 cm). We present 2-D maps of relative column density ("tau maps") obtained using our multiwavelength DISKFIT procedure (CSO images at 350 & 450 micron and Spitzer at 70 micron), assuming a two-grain model with characteristic grain sizes 1 mm and 18 μm. For our dynamical modeling of the larger dust grain components we assumed, following Wyatt (2003), that the grains are trapped in the mean motion resonances of a Neptune-mass planet orbiting at a radial distance of 65 AU from the star. Our results then suggest that the 4:3 resonance is populated by the mm-sized grains while the 2:1(u) resonance by the cm-sized grains, a situation that we attribute to the differing collision history of planetesimals in different resonances. Our detection of 4:3 resonance resolves an ambiguity in the location and orbital direction of the unseen planet. We can use our dynamical modeling to predict high spatial resolution images, observable by ALMA, of systems of this type, and thereby test (and further constrain) the models for these suspected planetary systems.

201 Methanol and deuterium fractionation in prestellar cores

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Despite progress in the understanding of interstellar medium chemistry, the abundance of some species remains unaccounted for. It is the case of methanol in cold and dense regions of the interstellar medium. Since ion-neutral gas phase reactions do not produce methanol efficiently, it has been suggested that methanol forms via active grain chemistry. According to molecule formation mechanisms on grain surfaces, methanol forms by successive additions of H atoms on formaldehyde. Comparison of deuterium fractionation in deuterated isotopes of CH_3OH and H_2CO can help constrain models. In order to test the hypothesis of grain surface chemistry, we have carried out a study of methanol and formaldehyde deuteration in a sample of prestellar cores. We present here the first results of this study, which indicate that although the deuterium fractionation ratios found are well reproduced by models, the absolute abundances are an order of magnitude higher than theoretical predictions. We discuss here the implications of this result.

202 Towards a 3D view of the dark cloud B68

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Juergen Steinacker, MPIA Heidelberg, Thomas Henning, MPIA Heidelberg

The discussion about how prestellar cores form and contract is currently entering a new phase. In the past, a simple 1-D analysis of core images was used to determine density profiles and to compare with profiles predicted by the different formation theories. This was justified by the moderate resolution of the instruments. However, there is now growing theoretical and observational evidence that core formation is essentially a 3-dimensional process. In the future, the increase in angular resolution and sensitivity with ALMA will reveal the small scale structure of prestellar cores and possible clumpiness, making a 3D modeling inevitable. We recently developed a method based on multiwavelength observations and 3D radiative transfer in order to determine the structure of pre-stellar cores in 3 dimensions. Here, we present the results of this method applied to the starless dark globule B68. The core had been interpreted before as a self-gravitating, isothermal, pressure-confined sphere of gas and dust in hydrostatical equilibrium. The analysis was based on the comparison of an azimuthally averaged radial dust column density profile by a Bonnor-Ebert sphere. However, projection and azimuthal averaging effects are a severe source of misinterpretation for structures seen in absorption. We find evidence for a significant deviation from the spherical symmetry. Moreover, the derived temperature distribution is not in agreement with the isothermal approximation. By calculating the ratio of the local thermal pressure and self-gravitational forces, we evaluate the validity of the hydrostatical equilibrium. Finally, the implications for the stability of the core are discussed.

203 Modeling the Orion KL survey carried out with the IRAM 30m telescope

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We have carried out a sensitive, fully single side band reduced and line confusion limited survey toward Orion KL with the IRAM 30 m telescope. We have covered all the frecuencies allowed by the 30 m (more than 168 GHz): 80-115.5 GHz, 130-179 GHz and 197-281 GHz. We have detected about 14000 resolvable lines of which near than 12000 are identified and attributed to 43 distinct molecules and 127 different isotopomer species. We present the modeling of Orion KL region using the lvg code created by J. Cernicharo. We report new calculations of the column densities of some molecules detected toward Orion KL. This work will be a good guideline for further studies using the ALMA capabilities in the submillimeter range.

204 The evolutionary state of the dense core Chamaeleon-MMS1: a combined APEX and Spitzer view

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We used the new submillimeter telescope APEX and the public database of the Spitzer Space Telescope to set constraints on the evolutionary state of the southern dense core Chamaeleon-MMS1 (Cha-MMS1),which will be an excellent target for ALMA. Our APEX observations reveal a high degree of deuterium fractionation in N_2H^+ and we do not find evidence for an outflow powered by Cha-MMS1. We report the detection of Cha-MMS1 at 24, 70 and 160 microns by the instrument MIPS of the SST, at a level nearly one order of magnitude lower than the young Class 0 protostars IRAM 04191 and L1521F. Bringing these submillimeter and far-infrared results together, Cha-MMS1 appears to have already formed a compact object, either the first hydrostatic core at the very end of the prestellar phase, or an extremely young protostar that has not yet powered any outflow, at the very beginning of the Class 0 accretion phase.

205 Results of a 200-hour BIMA Array Key Project to Study Gas Dynamics in the rho Ophichus cores

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James Di Francesco, Herzberg Institute of Astrophysics, Laura Fissel, University of Toronto

We present results from a large project to probe the gas dynamics in the rho Ophiuchus cores using the Berkeley-Illinois-Maryland Association (BIMA) array. We have combined the interferometric data with single dish 13CO 1-0 maps from FCRAO, taken as part of the COMPLETE survey. We present results of these observations, as well as SCUBA polarimetry data on the magnetic field within the rho Oph cores from the JCMT archive. Taken together, we compare the gas kinematics on clump scales to the morphology of the magnetic field to search for large scale motions along mean field directions.

206 Search for CCO and CCCO in low mass star forming regions

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M. Elisabetta Palumbo, INAF-OACt, Italy, Claudia Siringo, University of Catania and INAF-OACt, Italy , Paolo Leto, INAF-IRA, Noto, Italy

We have searched for CCO and CCCO in the gas phase towards 9 lines of sight in low mass star forming regions with the 32-m radiotelescope in Noto (Italy). Preliminary results indicate that the transition at 38.4 GHz of CCCO has been detected towards two lines of sight in the Taurus Molecular Cloud, namely TMC-1 (confirming previous results) and Elias 18 (a new detection). The origin of CCO and CCCO in these regions in not yet clear. In dense molecular clouds during the collapse phase high CO depletion is observed and it is believed that gas phase CO freeze out on dust grains forming CO-rich icy grain mantles. These suffer from cosmic ion and UV irradiation during the collapse and the sublimation phase caused by the new formed protostar. When sublimation takes place volatile species, such as CO, are released back to the gas phase. Laboratory experiments have shown that carbon chain oxides are formed after ion irradiation and UV photolysis of CO-rich ice mixtures. Based on these laboratory results we suggest that CCO and CCCO detected in dense molecular clouds are formed in the solid phase after irradiation of CO ice mantles and released to the gas phase after sublimation of volatile mantles. Alternatively it has been suggested that CCO and CCCO are formed after ion-molecule gas phase reactions. One of the mysteries of interstellar chemistry is the mechanism regulating the balance between gas phase and solid phase species. Carbon chain oxides could be key molecules in this field and thanks to its high sensitivity and resolution ALMA will give important results.

207 Resolving the dust emission in the Vela Molecular Cloud

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Teresa Giannini, INAF-Osservatorio Astronomico di Roma, Dario Lorenzetti, INAF-Osservatorio Astronomico di Roma, Brunella Nisini, INAF-Osservatorio Astronomico di Roma, Fabrizio Massi

Studying the star formation activity in the Vela Molecular Ridge (VMR, $d \sim 700$ pc), we have found a region of about 1 square degree characterized by high efficiency in producing both young embedded clusters and isolated stars. We mapped the dust continuum emission at 1.2 mm (SEST telescope, 24 arcsec resolution), discovering 29 peaks along with 26 unresolved structures. Ten out of these latter present a clear association with IRAS/MSX sources and/or H_2 jets. At the VMR distance, a spatial resolution of sub-arcsec scale, hopefully available also in the early phases of ALMA, allows us to investigate these structures where individual/low mass objects will likely form. Our expectation is to resolve structures smaller than 1000 AU, like the ones observed in low mass and closeby star forming regions (eg. Oph). This circumstance is crucial to: i) define the low-mass end of the clump mass function. ii) morphologically investigate substructures in extended clumps; iii) link the dust emission with observed jets and molecular outflows; iv) resolve dust structures in correspondence with clusters; v) clarify the connection between dust emission peaks and IRAS/MSX sources.

208 Searching for massive pre-stellar cores through observations of N2H+ and N2D+

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Paola Caselli, INAF-OAA, CfA, Antonio Crapsi, Leiden Univerity, Riccardo Cesaroni, INAF-OAA, Jan Brand, INAF-IRA

We present observations of N2H+ and N2D+, obtained with the IRAM-30m telescope, towards a sample of candidate massive protostars. Our aim is to determine the deuterium fractionation in these sources, by means of the column density ratio N(N2D+)/N(N2H+)=Dfrac. The mean value of Dfrac is 0.015, which is orders of magnitude higher than the cosmic D/H abundance, suggesting the presence of cold and dense gas with chemical/physical properties close to those found in low-mass pre-stellar cores. In principle, such gas can be associated with the gaseous envelope of the massive forming star, or distributed in one (or more) pre-stellar cores located close to it. Due to the poor angular resolution of our data, we cannot distinguish between the two scenarios. Observations at higher angular resolution (with PdBI, SMA, CARMA and ALMA in the near future) will allow us to solve this problem.

209 **Star forming globules**

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Claudio Codella, INAF-IRA Firenze, Luca Di Fabrizio, INAF-TNG La Palma, Fabrizio Massi, INAF-Arcetri, Jan Wouterloot, JAC Hilo Hawaii

We have been investigating the low-mass star forming process in the Bok globule CB230 through NIR and mm wavelengths observations. A bright hot jet component emanating from a deeply embedded YSO has been found in the 1.64 μm line of [FeII], suggesting the presence of dissociative J-type shocks. The jet is composed of two well-defined knots. The H_2 emission at 2.12 μm associated with this jet is fainter and wider than the [FeII] emission, and is likely coming from the walls of the jet-channel. The YSO-jet system is located at the base of a large-scale molecular outflow. The [FeII] and H_2 emission have been confirmed by the detection of several bright NIR lines towards the jet as well as towards the driving YSO. We will present these observations and discuss the results of the analysis in terms of the mass-loss activity from the YSO and how it affects the high density medium surrounding it.

210 **Cold molecular gas in cooling flows**

F. Combes, Observatoire de Paris, LERMA,
P. Salome, IRAM, Grenoble

The problem of the cooling of the gas towards the central galaxy in clusters is still an open question. Recent X-ray data from Chandra and XMM-data have given a new view of the cooling flow problem, pointing out the existence of some re-heating mechanisms. Cold molecular gas has been found in several cooling flow clusters cores with single dish telescopes in the last few years. Plateau de Bure maps have also been build showing, for the very first time, images of the cold gas in those environment. We will focus here on the description of the NGC 1275 galaxy, at the center of the Perseus cluster. Large molecular gas filaments around the galaxy have been revealed through CO(1-0) and CO(2-1) emission lines, following the very peculiar Halpha filamentary structure known around the central galaxy and certainly tracing, in some part, accreted gas toward the central object.

211 The JCMT Spectral Legacy Survey

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Frank Helmich, SRON , Rene Plume, University of Calgary, Helen Roberts, University of Manchester, Floris van.der.Tak, SRON, The SLS Collaboration

Molecules provide the only probes which can reveal the dynamics, physics, chemistry and evolution of the cold dense regions of molecular clouds in which stars form. The JCMT Spectral Legacy Survey (SLS) is being undertaken to study the molecular inventory of a sample of molecular cloud sources. The observations will be used to investigate how the molecular properties of a source are related to the physical conditions in the gas and the source's evolutionary status. Using the new 16 pixel 345 GHz array receiver HARP-B on the James Clerk Maxwell Telescope (JCMT), the SLS will produce spectral scans of five sources over the frequency range 330 GHz to 360 GHz. For every spectral channel throughout this frequency range of the survey will produce a fully sampled $2' \times 2'$ image. The five target sources to be observed have been selected to span a range of different evolutionary stages and different physical environments in molecular clouds. The SLS has been allocated a total of 187 hours observing time and will start in mid-2007. All the data and products from the survey will become publicly available at the end of the survey. In this presentation I will discuss the strategy and goals of the SLS.

212 The gas-to-dust ratio near stars and protostars in the Taurus Molecular Cloud

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Marc Audard, Columbia University, USA, Kevin Briggs, PSI, Switzerland, Adrian Glauser, PSI, Tracy Huard, CfA, Cambridge, USA, Francois Menard, LAOG, France, Thierry Montmerle, LAOG, Deborah L. Padgett

The gas-to-dust (G/D) mass ratio, amounting to approximately 100 in the interstellar medium, may be altered in molecular clouds and circumstellar disks due to dust evaporation, dust settling, condensation of gas etc. Measurements of G/D around stars in dense molecular environments are challenging since they involve strongly extincted sources of light. We present a study of measuring G/D along the lines-of-sight toward T Tau stars and protostars. To estimate G/D, we interpret the ratios between the gas absorption column densities measured from X-ray absorption, and optical-to- infrared extinction by dust, and compare these ratios with interstellar values. Alternatively, detailed 3-D dust-disk modeling provides the dust column, although this technique can be used only in exceptional cases for which high-quality images are available. Our X-ray absorption data are derived from a survey of the Taurus region performed with the XMM-Newton satellite, while the mid-IR and optical data are from large surveys of the same region performed with the Spitzer Space Telescope and CFHT, respectively. Near-IR data have also been added from 2MASS.

213 ALMA sample selection in the Gould's Belt

Jennifer Hatchell, University of Exeter

ALMA has the potential to reveal the details of mass accretion, ejection and disk evolution in protostars, and, unlike current interferometers, the collecting area and fast imaging ability needed to observe moderate-sized samples rather than individual objects and therefore put the results on a firm statistical footing. Surveys of nearby star forming regions are an excellent resource from which samples for ALMA can be selected. We describe here two such surveys: the submm-wavelength JCMT Gould's Belt survey of local star formation; and its mid-infrared counterpart, the Spitzer Gould's Belt survey. Combined, these surveys can be used to select samples of starless, protostellar and pre-main-sequence objects in nearby star-forming clouds for followup with ALMA.

214 Water maser emission in Bok globules

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We report the most sensitive water maser survey towards Bok globules to date, using NASA's 70 m antenna in Robledo de Chavela (Spain). We observed 207 positions within the catalog with a higher possibility of harboring a young star, using as selection criteria the presence of radio continuum emission (from submillimeter to centimeter wavelengths), geometrical centers of molecular outflows, peaks in maps of high-density tracers (NH_3 or CS), and IRAS point sources. We also present a statistical study of our selection criteria as predictors for the presence of maser emission.With this survey we have increased the number of Bok globules known to emit water masers from 3 to 9. These results have been complemented with VLA high-resolution observations towards our most interesting detections, which are CB 3, CB 54, CB 65, CB 101, CB 232, and CB 205. We have used the accurate positions of the maser emission to derive information about the powering source of the masers, their relation with molecular outflows, and the kinematical properties of these regions. We also present single-dish observations of millimeter and centimeter spectral lines towards CB 101 (IRAS 17503−0833) and CB 65 (IRAS 16277−2332) in order to study the unknown nature of these sources.

215 Maps and Results from the SCUBA Public Archive

James Di Francesco, National Research Council of Canada,
Doug Johnstone, National Research Council of Canada, Helen Kirk, University of Victoria, Todd Mackenzie, University of Prince Edward Island, Elizabeth Ledwosinska, McGill University

The Submillimetre Common User Bolometer Array (SCUBA) was one of the flagship instruments of the James Clerk Maxwell Telescope (JCMT). Since 1997, SCUBA was used regularly to observe simultaneously the 850 micron and 450 micron continuum emission from a variety of astronomical phenomena, including cold dust in Galactic star-forming regions, at respective resolutions of 14 arcsec FWHM and 7.5 arcsec FWHM. Cryogenic problems regrettably cut short SCUBA's continued operation in 2005. A successor instrument, SCUBA-2, is planned for installation on JCMT in late 2006. To maximize the scientific relevance of SCUBA, we have re-reduced all 850 micron and 450 micron jiggle-map and scan-map data (of objects outside the Solar System) within the SCUBA archive, located at the Canadian Astronomical Data Centre (CADC). The SCUBA data, totaling 28,007 separate observations, consist of all those publicly available as of August 2005. A total of 3080 maps at, each 1.2 deg $\times$ 1.2 deg in extent, were made using a matrix inversion technique and the most up-to-date facility determinations of extinction and flux conversion. Specifically, data at the same location but from several epochs were combined into a single map to maximize sensitivities. Common map artifacts were removed via flattening and edge-clipping algorithms. An automatic object identification algorithm was used to compile new catalogues of objects detected by SCUBA; the 850 micron catalogue alone contains 2820 objects. All newly reduced maps and the catalogues will soon be made available for public access via the CADC (http://cadc.hia.nrc.ca)

216 Sulfur chemistry in the Horsehead PDR

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We present $3.65' \times 3.34'$ angular-resolution IRAM *Plateau de Bure Interferometer* (PdBI) observations of CS toward the Horsehead *Photodissociation Region* (PDR), complemented with IRAM-30m single-dish observations of several rotational lines of CS, $C^{34}S$, HCS^+ SO, H_2S and several other S-bearing species. We have already analysed the CS and HCS^+ photochemistry, excitation and radiative transfer to obtain their abundances and the physical conditions prevailing in the cloud edge. Since the CS abundance scales to that of sulfur, we determine the gas phase sulfur abundance in the PDR, an interesting intermediate medium between translucent clouds (where sulfur remains in the gas phase) and dark clouds (where large depletions have been invoked). We find that very low sulfur depletion values can explain the CS and HCS+ abundances in the PDR. Aperture synthesis observations contain detailed information about density, temperature, abundance and structure of PDRs, but only detailed radiative transfer and photochemical models adapted to each source are able to extract the information. Future observations with ALMA, together with sophistication in PDR modeling, will allow us to characterize in much more details many energetic cloud surfaces such as the PDRs.

217 Rotational state-to-state rates and spectral representation for inelastic H_2:H_2 collisions at low temperature

Jose M. Fernández, Instituto de Estructura de la Materia CSIC, Madrid, Spain,
Salvador Montero, IEM CSIC, Franck Thibault, Université de Rennes, France, Guzman Tejeda, IEM CSIC

Inelastic collisions in natural H_2 in its vibrational ground state are studied from the experimental and theoretical points of view between 10 and 140 K. Number densities and rotational populations are measured by Raman spectroscopy along supersonic expansions of H_2. State-to-state rate coefficients $k_{ij\to\ell m}$ for the collisional process

$$mH_2(i)+mH_2(j)\to mH_2(\ell)+mH_2(m),$$

where i,j,ℓ,m are the rotational quantum numbers of the involved molecules, are calculated in the closed-coupled scattering approach with the MOLSCAT code employing the *ab-initio* H_2-H_2 potential by P. Diep and J. K. Johnson (2000). The calculated rates are assessed by means of a master equation (describing the time evolution of the spectroscopically determined rotational populations) which provides the link between theory and experiment. The feasibility for obtaining the rates on the sole basis of the experiment is discussed. The dominant rate coefficients in the investigated thermal range are found to be $k_{21\to01} > k_{30\to12} > k_{31\to11}$, proving the importance of mixed up-down processes like $30\to12$. Good agreement is found between experiment and theoretical calculations, as well as with earlier measurements of rotational relaxation times by ultrasonic velocity dispersion. A spectral representation is proposed in order to quantitatively visualize the collisional contributions to any time evolving process, regardless of its equilibrium or non-equilibrium character.

218 Terahertz spectroscopy of $N^{18}O$ $X^2\Pi$ - Combined analysis with microwave studies

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NO is a well-known stable radical observed in space. Many studies including isotopomers have been carried out but it was only recently that the direct transitions between two spin components (Ω = 1/2 and 3/2) was observed. The terahertz spectra of ^{14}NO and ^{15}NO were observed by Varberg et al and the spin-orbit constant was determined precisely. The $N^{18}O$ radical was observed up to 1 THz region. This paper reports observation of the terahertz spectra of $N^{18}O$ by the Evenson-type tunable far-infrared spectrometer (TuFIR). Although it was possible to observe $N^{18}O$ in its natural abundance at room temperature, commercially available enriched sample was used to get better S/N. The direct transition between the two spin components at about 3.7 THz was successfully observed and it lead the precise determination of the spin-orbit coupling constant. The combined analysis with the previous microwave results and comparison with other isotopomers will be given.

219 IC4406: a radio-infrared comparison

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Corrado Trigilio, INAF, Italy

IC 4406 is a large (about 100”) southern bipolar planetary nebula, composed by two elongated lobes, extending from a bright central region, where there is evidence for the presence of a large torus of ionized gas. In this poster we show new observations of this source performed with IRAC (Spitzer Space Telescope) and the Australia Telescope Compact Array. Although the possibility for faint extended emission to be missing in the radio maps cannot be ruled out, flux from the ionized gas appears to be concentrated in the bright central region. Comparing ATCA to IRAC images, it seems that, like in other planetary nebulae, ionized and neutral components spatially co-exist in IC 4406.

220 Physical and Chemical diagnostics from HCN: accounting for its hyperfine anomalies

Robert Loughnane, NUI Galway

Rotational transitions of molecules and molecular ions serve as tracers of cold dense regions of star forming molecular clouds. In order to probe the star formation process mulitple species and transitions are required to self-consistently determine the chemical and physical structure of such clouds. HCN is a potentially highly useful molecule and is already, in advance of ALMA, readily observable but the interpretation of its spectra is hampered because it exhibits anomalies in the relative intensities of its individual hyperfine lines. Such anomalies result from selective photon trapping. We present an approximate method for modelling the radiative transfer in HCN that should allow this molecule to become a useful tracer of physical and chemical conditions for the first time.

221 A 3 mm Line Survey of the Simplest Star Forming Regions

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Molecular line surveys provide an important tool to obtain a complete view of the physical properties, chemical complexity and kinematics of molecular clouds. We have carried out the first spectral line survey at $\lambda = 3$ mm towards cold condensations which are potential sites of low-mas star formation, using the IRAM 30-m telescope at Pico Veleta (Spain). For this study we selected four sources at different stages of evolution, ranging from prestellar cores to those containing class 0 objects, in order to characterize their molecular emission and study the chemical processes ocurring during the collapse phase. In our 86-93 GHz scan we have observed 33 different molecular species and sereval unidentified lines. We have detected some common molecules like HCN, HNC, HC_3N, HCO^+ and their isotopomers, and other interesting molecules like HCO, HNCO, CCS, SO, formic acid (HCOOH) and deuterated substitutions of ammonia, methanol and thioformaldehyde. Here we present the first results of the survey: the molecular detections and the obtained column densities and abundances. An analisys of the data allows us to connect those quantities to the physical conditions and the evolutionary stage of the different studies cores. Unbiased surveys reveal the presence of unexpected molecular species and hence provide complementary information for the study of prestellar cores. In the near future, we will use complementary studies in order to understand the chemistry, the kinematical signatures of the different molecules, the physical properties, etc. at the early stages of low-mass star formation.

222 Turbulence in the Southern Galactic Plane: The Mopra DQS survey of the G333 region

Maria Cunningham, University of New South Wales,
Nadia Lo, University of New South Wales, Michael Burton, University of New South Wales,, Tony Wong, Australia Telescope National Facility, Paul Jones

We are undertaking a multi-molecular line survey of a 1×1.5 degree region of the southern Galactic plane using the new broadband capabilities of the Mopra telescope at Coonabarabran in Australia. In 2004 and 2005 we have made maps in ^{13}CO, $C^{18}O$, CS and $C^{34}S$, while during 2006 we will observe up to 16 different transitions with the new MOPS 8-GHz digital filter bank, including HCN, HNC, HCO^+, SO, N_2H^+, CH_3OH and CH_3CN. The spatial resolution of the resulting data cubes is around 35 arcsec, with a velocity resolution of 0.2 km s^{-1} . The aims of this project are to 1) observationally determine the turbulent properties of the dense gas where star formation takes place, 2) determine the sources of energy that drive turbulence, and how these properties relate to star formation. By observing molecular transitions that are sensitive to different densities over the same physical region, we aim to measure the density contrasts produced by turbulence and gain crucial information about the origin and nature of turbulence in the dense interstellar medium (see Ballesteros-Paredes and Mac Low 2002). We are using a variety of methods to characterize the density and velocity structure of the different tracers, including clump finding algorithms and power spectra and delta-variance methods. Here we present the preliminary results for the 2006 Austral winter observing, and discuss how effectively emission from the different molecular tracers constrains the turbulent properties of the molecular gas.

223 **Modeling Tools for Molecular-Line Astronomy at Submillimeter Wavelengths**

Michiel Hogerheijde, Leiden Observatory,
Floris van der Tak, Space Research Organization, Groningen

We present an overview of several modeling tools for analyzing molecular line data at submillimeter wavelengths. These tools are already proving to be very valuable for the interpretation of data obtained with current day telescopes, and will be indispensable for data obtained with ALMA. The tools summarized in this poster include: LAMDA, the Leiden Atomic and Molecular Database containing a collection of collisional excitation rates and spectroscopic data, and forming input for: RADEX, an on-line and off-line program to calculate non-LTE excitation and line emission from a homogeneous medium, based on the escape probability method; and RATRAN, an accelerated Monte Carlo code to solve radiative transfer and molecular excitation in spherical and cylindrical symmetry. We present several real-life examples of how these tools can be used in conjunction with existing data reduction packages to quantitatively interpret (sub) millimeter interferometer observations. The described tools are publically available at `www.strw.leidenuniv.nl/~moldata`.

224 **A detailed modelling of the chemically rich clumps along the CB3 outflow**

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Jeremy A. Yates, University College London, Serena Viti, University College London, Claudio Codella, INAF-Istituto di Radioastronomia

In order to investigate the origin and the structure of the low velocity, chemically rich clumps observed along the lobes of low- and intermediate-mass outflows, we construct a detailed model of the S1 clump along the CB3 outflow. We use a time-dependent chemical model coupled with a radiative transfer model to reproduce the observed line profile for a direct comparison with previous observations of this clump. We find that the simultaneous fitting of multiple species and transitions is a powerful tool in constraining the physical parameters of the gas. Different scenarios for the clump formation have been investigated. The models that better reproduce all the observed lines are those where the clump is formed, at least partially, before the advent of the outflow; with the advent of the outflow the clump undergoes a short period of non-dissociative shock and the consequent release of the icy mantle together with the high temperature chemistry leads to the observed chemical enrichment. Our results also suggest the presence of substructure within the clump: a more extended component traced by CS, SO and the lower energy transitions (3_K-2_K and 2_K-1_K) of CH_3OH, and a more compact component traced by H_2CO, SO_2 and the higher energy transitions (5_K-4_K) of CH_3OH.

225 Probing the radio source environments using absorption lines

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Tapasi Ghosh, NAIC, Arecibo, D.J. Saikia, NCRA-TIFR, C.J. Salter, NAIC, Arecibo, R. Srianand, IUCAA, S. Jeyakumar, Instituto de Geofisica, UNAM

We present the results of a 21cm and OH absorption search towards a sample of radio sources using the Arecibo 305-m telescope and Giant Metrewave Radio Telescope (GMRT). Our sample includes GPS sources (size $<$1 kpc), CSS sources ($\sim$1-20 kpc) as well as the larger FRI and FRII sources and allow us to probe the environments of these sources on a variety of scales. These observations along with the data at other wavebands have allowed us to constraint the distribution and kinematics of cold gas in the central regions of these active galaxies. We discuss the dependence of observed gas properties probed via absorption lines on cosmic epoch and radio source properties.

226 Looking for more evidence for transient clumps and gas chemical evolution in dense cores of molecular clouds. Multitransitional observations in HH 43

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Josep Miquel Girart, Institut de Ciències de l'Espai (CSIC-IEEC), Robert Estalella, Departament d'Astronomia i Meteorologia, Universitat de Barcelona

We recently found observational evidence that the region around the starless CS core of L673 is constituted by a heterogeneous medium of condensations, of various densities and at various stages of chemical evolution. This result seems to confirm the theoretical prediction made several years ago that molecular clouds are clumpy on a scale that is normally unresolved and that most of these clumps simply dissipate into an interclump medium on a timescale on the order of 1-2 Myr (Taylor et al. 1996). The observations were part of a multimolecular, multitransitional study at moderate- and high-angular resolution using single-dish and interferometric telescopes, respectively. We found that the clumpy structure detected with the BIMA telescope in L673 was real. We detected a total of 15 clumps in our data cube, all of them resolved in our angular resolution. Recent theoretical models of the gas of dense cores of molecular clouds are starting to reproduce, still qualitatively, the characteristics of our maps at different angular resolutions. We will present the results obtained in the region HH 43, where we have carried a multitransitional study similar to the one we made in L673, using the BIMA telescope for the high-angular resolution observations, complemented by the single-dish observations at moderate-angular resolution carried out with the FCRAO telescope. The HH 43 region is more evolved than the fairly quiescent gas of the CS core of L673 and shows tracers of star formation, such as IR sources and HH objects. The clumpy structure seems also apparent and it may provide us with information on how the clumpy structure is affected by the star-formation processes.

227 **Benchmarking PDR models against the Horsehead edge**

Jérôme Pety, IRAM Grenoble

In the past twenty years, many observations have been undertaken and sophisticated chemistry and radiative transfer models have been built to understand the evolution of the interstellar matter from diffuse gas to protoplanetary disks through molecular clouds. Despite this considerable effort, several chemical problems stay unsolved today. For instance, while CS can be shown to result from the observed amounts of HCS^+ in diffuse clouds, we do not understand how to form so much HCS^+ in this medium (Lucas & Liszt 2002). To prepare for the unprecedented spatial and spectral resolution provided by ALMA and Herschel/HIFI, chemical models are being benchmarked against each others (`http://www.ph1.uni-koeln.de/pdr-comparison/intro1.htm`). It is obvious that chemical models also need well–defined observations that can serve as references. Such a reference must include a detailed description of the source geometry and of the thermal and density structures. Photo-dissociation regions (PDRs) are particularly well suited to serve as references because they make the link between diffuse and molecular clouds, thus enabling astronomers to probe the largest variety of physical and chemical processes. The Horsehead nebula (Barnard 33) appears as a dark patch on the sky with an extent of $\sim 5'$ seen against the bright HII region IC434. The mane of the Horsehead is a PDR viewed nearly edge-on (the PDR front is inclined on the plane–of–the–sky by less than 6deg) and illuminated by the O9.5V star σOri. At a distance of 400 pc, the Horsehead nebula offers the opportunity to study at small linear scales ($1'$ corresponding to 0.002 pc) the physics and chemistry of a PDR with a particularly well understood and simple geometry. The Horsehead PDR is thus very close to the prototypical kind of source (i.e. 1D, edge-on) needed to serve as a reference to models. In this talk, I will first describe the findings of our previous studies: 1) Horsehead has a very steep gradient, rising to $n_H = 10^5\ cm^{-3}$ in less than $10''$ (i.e. 0.02 pc), at a roughly constant pressure of $P = 4 \times 10^6\ K\,km\,s^{-1}$; 2) The abundances of the hydrocarbons are higher than the predictions based on pure gas phase chemical models suggesting that an additional formation path of carbon chains should be considered in PDRs; 3) Using the most recent CS collisional and chemical rates to account for CS and HCS+ abundances, we derived much lower sulfur depletion in Horsehead than in previous studies. I will then open the talk on on-going projects, i.e. constraining 1) the temperature profile through high J CO lines and 2) the fractional ionization across the PDR using HCOp maps. Our long term goal is to give PDR models an observational benchmark through well constrained mm and sub-mm observations of a "simple' source by making the data and results available through a dedicated web page after publication. Bibliography Abergel A. et al., 2003, A&A 410 577
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228 **The CO outflow from IRAS 18316-0602 in G25.65+1.05**

Paul Jones, formerly Australia Telescope National Facility,
Maria Cunningham, University of New South Wales, Snezana Stanimirovic, UC Berkeley

IRAS 18316-0602 (RAFGL7009S) is a deeply embedded massive young stellar object associated with the compact H II region G25.65+1.05. There is a bipolar outflow traced by CO and shocked H_2. We present observations of ^{12}CO and ^{13}CO (1-0) from the BIMA interferometer and the single-dish Mopra telescope.

229 The Gas Disk and Outflow of HH 30 Unveiled by the Plateau de Bure Interferometer

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F.Gueth (IRAM Grenoble), S.Guilloteau (L3AB Bordeaux), A.Dutrey (L3AB Bordeaux)

HH30 is a well-known Pre-Main-Sequence star in Taurus. HST observations have revealed a flared, edge-on disk driving a highly-collimated optical jet (Burrows et al 1996). With the Plateau de Bure interferometer, we obtained high angular resolution ($\sim ''$) observations of the dust continuum at 2.7 and 1.3 mm, and of the ^{12}CO(2-1), ^{13}CO(2-1), ^{13}CO(1-0), C^{18}O(1-0) emissions around HH 30. This object is a case study for the disk-jet-outflow paradigm, being so far the only star to display a jet and outflow connected to a well defined Keplerian disk. We used a standard disk model to fit the ^{13}CO(2-1) uv-plane visibilities and derive the disk properties and the stellar mass while an ad hoc outflow model was used to reproduce the main properties of the ^{12}CO(2-1) emission. The main results are as follows. The disk rotation is Keplerian: Using a distance of 140 pc, we deduce a mass of $0.45 M_{\odot}$ for the central star. The disk outer radius is 420 AU. The outflow presents to first order a conical morphology with a 30 degree half opening angle and a constant (12km s^{-1}) radial velocity field. Outflow rotation was searched but not found. A high velocity "bullet" is seen 1000 AU away from the star. HH 30 is a low mass TTauri of spectral type around M1 and age 1 to 4 Myrs, surrounded by a medium size Keplerian disk, of mass around $4.10^{-3} M_{\odot}$. It reveals a surprisingly asymmetric (one-sided) outflow despite a relatively symmetric jet. These observations do not enable to assign the origin of the molecular outflow to entrainment by the optical jet or to a disk wind. In the latter hypothesis, the lack of rotation would imply an origin in the inner 15 AU of the disk.

230 FIR lines from clumpy PDRs tracing structures from kpc to 100 AU scales

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Markus Cubick, University Cologne, Markus Röllig, University Cologne / University Bonn, Carsten Kramer, University Cologne

Using the FIR emission of our Galaxy as observed by the FIRAS instrument on-board the COBE (cosmic background explorer),we can derive properties of the emitting regions. Combining the measured transitions of high-J CO, [CI], [CII], and [OI] with ground-based observations of CO isotopes, [CI] and other species at higher resolution allows to derive a self-consistent model of the dense ISM in the Galaxy where most of the FIR line emission can be attributed to clumpy PDRs (photon-dominated regions). Using the clumpy KOSMA-tau PDR model to fit the observational data we can give a self-consistent explanation of all observed lines when using a clump mass spectrum $dN/dM \propto M^{-\alpha}$ with $\alpha \approx 1.7$ and a corresponding mass-size relation. Individual clumps must have sizes between 500 AU and 0.5 pc. With the prospects of Herschel and ALMA we will be able to study that structure in much more detail, where Herschel will complete our knowledge on the chemical structure of PDRs by observing many species in their ground state unseen before and provide, for the first time, velocity resolved data allowing to study the kinematic structure in detail. ALMA will actually resolve the clumpy structure down to the scales of the smallest clumps dominating the properties of the UV radiative transfer in PDRs.

231 Class I Methanol Masers as signposts of early star formation

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Class I methanol masers are found in the vicinity of regions of high mass star formation. Several studies have shown them to be associated with outflow activity which is consistent with a collisional pumping mechanism. A search for these masers conducted at Haystack Observatory has found several new maser positions in regions with previously unknown star formation activity or offset from the centers of star formation. Several of the Class I masers do not appear to be associated with near infrared sources seen in images from the Spitzer space telescope. Several sources also do not have previously known star formation associate with them. In particular, masers in W75N are situated 1.5′ southwest of the center of star formation. This maser appears to be within the extended molecular outflow and possibly coincident with several knots seen in 2.2 micron H_2 emission. A new maser source in the W75S/DR21 region is situated about 2.5′ north of DR21OH. These observations appear to indicate that the Class I methanol masers arise in regions of very early star formation and could possibly be used to detect these young protostars. We will present multi-wavelength observations (at 36, 44, 95 and 147 GHz) of the Class I masers, and how they may be used to put constraints on the age of the protostar. We will focus on the implications of these results in the understanding of the high mass star formation process and the physical conditions that exist in these regions that result in the maser excitation. We will also discuss the role of ALMA in the study of methanol masers and their connection to early star formation.

232 The Galactic center molecular clouds. A peculiar shock chemistry

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In the central few 100 pc of the Galaxy one detects widespread high abundance of grain processing molecules, like methanol, ethanol, and silicon monoxide, with large spatial variations within the central molecular zone. The origin of the variations in the chemical complexity are likely ascribable to the different processes that have taken place in the Galactic center. Shocks have been invoked to explain the high abundances of refractory and complex organic molecules in the gas phase. Requena-Torres et al. (2006) have shown that large abundances of larger molecules like $(CH_3)_2O$ or $HCOOCH_3$ can be also observed in those molecular clouds and their large abundances suggest that can be formed on grain mantles and ejected from them by shocks. Recent observations with the Green Bank telescope in the cm-range have shown that the chemistry of Sgr A and Sgr B2 regions is more complex than previously expected. Large molecules, observed only in the hot core Sgr B2N, have been observed in different regions of the GC molecular clouds and we have also detected large cyanopolyynes observed previously in dark clouds and evolved stars. The chemistry in these regions shows a large complexity that have not been observed before in any other region and that have to bee compared with other nucleus of galaxies. The new ALMA capabilities will be important for the understanding of all the behaviors on the complex chemistry of this impressive region, the Galactic center molecular clouds.

233 The Methanol Multibeam Survey of the Galactic Plane

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We are carrying out a systematic survey of the Milky Way for 6668-MHz methanol masers using a new 7-beam receiver jointly constructed by Jodrell Bank Observatory and the ATNF for use on the Parkes and Lovell Telescopes. The 6668-MHz methanol maser exclusively traces massive star-forming regions at an early stage in their evolution. The whole galactic plane is being surveyed within latitudes $\pm 2^{\circ}$, with a velocity resolution of 0.1 km s^{-1} and a 5-σ sensitivity of $\sim$0.7 Jy. The methanol multibeam (MMB) survey is the most sensitive survey yet undertaken for massive young stars in the Galaxy, and will provide the first unbiassed catalogue of these objects. The MMB receiver was commissioned at Parkes Observatory in January 2006. The first 40 days of observing yielded 470 sources, of which 201 are new discoveries. The Parkes survey is expected to take 100 days, after which the receiver will be moved to Jodrell Bank to complete the survey of the northern galactic plane. As an integral part of the survey, the ATCA and MERLIN are being used to determine accurate (0.01-0.1 arcsec) positions for the masers, which are then cross-correlated against other galactic surveys to identify counterparts at other wavelengths. The MMB catalogue will provide a major resource for follow-up observations with ALMA and other instruments.

234 Formation mechanism of dense clumps in the NGC 7538 Region

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We have carried out the observations of various molecular emissions in the molecular cloud NGC7538 region. In the western region of IRS11, we have found the dense gas has a shell-like structure with a central cavity. The velocity structure within the cavity suggests an expanding motion. The line widths of the clumps on the shell-like structure tended to be broader than ones of the others. Our map of the CO (J=1-0) emissions suggested the existence of the giant outflow. Although the whole structure remains unclear due to the contaminations of the background emissions, we assumed the outflow has the same properties as the outflow from the Orion IRc. In our estimation, the momentum and the energy of the expanding motion could be supplied from a giant molecular outflow. In addition to the broader line width, the masses of the clumps on the shell-like structure tended to be larger than ones of the others. Thus, we may conclude this outflow induced the formation of the dense clumps along the expanding shell.

235 **Molecular emission ahead of Herbig-Haro objects**

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We present IRAM-30 m observations of molecular emission ahead of four Herbig-Haro (HH) objects. Several positions where observed for each object. By comparing column densities among the several clumps we attempt a very simple chemical analysis in light of a photochemical model (quiescent clumps exposed to the radiation generated in the HH objects) . We find that the abundances of the observed species ahead of the surveyed HH objects are higher than those found in a typical starless core and that by comparing the column densities among the different clumps we find that the clumps ahead of HH 7-11, HH 34 and HH 1 are of the same chemical nature, supporting the idea that the gas ahead of all HH objects exhibit a rich chemistry.

236 **Capabilities of Herschel-HIFI to study Water and the Molecular Universe**

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Emmanuel Caux, CESR, Tom Phillips, CalTech, Juergen Stutzki, KOSMA, Xander Tielens, ARC, Frank Helmich, SRON/Kapteyn Inst., on behalf of the HIFI consortium

The Heterodyne Instrument for the Far-Infrared is one of the three instruments to be launched on-board of ESA's Herschel Satellite in 2008. It is a very high resolution spectrometer optimised to survey, over the widest possible spectral range and with state-of-the-art sensitivity, the unexplored Far-Infrared. We will present the updated scientific capabilities of HIFI and several unique science cases that can only be addressed with HIFI.

237 Coupled chemical/RT transfer models of dark cores

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Jonathan Rawlings, Univ College London, Jeremy Yates, Univ College London, Serena Viti, Univ College London

We shall present the rationale of a theoretical study which addresses the chemical and dynamical evolution of dark cores making use of coupled time dependent chemical network/line radiative transfer models. The synthetic line spectra for various molecular species can be used to constrain the chemo-dynamical state of the cores via comparison with detailed observations.

238 Io's SO2 atmosphere : first disk-resolved millimetric interferometric observations

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We present observations of Io's SO_2 atmosphere obtained with IRAM-PdBI and their modeling. We recorded data on leading and trailing sides on winter 2005. The interferometer was in A configuration, providing a $0.5'' \times 1.5''$ HPHW synthetized beam at 1.3 mm, so Io was resolved in the longitudinal direction. The continuum data is fitted for a surface temperature of 100K, low variations across the surface and a constant surface emissivity, which suggest sub-surface sounding. The SO_2 216.643 GHz line was fitted through a radiative transfer model based on given SO2 distributions inferred from IR disk-integrated (Spencer,2005) or HST disk-resolved UV data (Feaga,2006). The SO_2 line is detected on both hemispheres. Disk-integrated and disk-resolved SO2 lines on the leading side respectively show a 800m s^{-1} width and a 400m s^{-1} limb to limb spectral shift difference, that imply a Doppler broadening effect such as a superrotating wind of 380m s^{-1}. Line contrast on leading implies 150-210 K atmospheric temperatures. SO_2 line emission maps exhibit spatial shift with respect to continuum emission, showing that SO_2 emission is not homogeneous across the disk. On the leading side, the spatial shift is in the East-sky direction, which is roughly reproduced by the models.However, data map shows narrower SO_2 emission than model maps, suggesting a more localised emission. On the trailing side, the SO_2 is shifted to the North, which may suggest volcanic emission. The next step will be to test the plume models made by Zhang et al.(2003). The ultimate goal of this work is to distiguish between SO_2 ice sublimation and volcanic outgassing as possible origins for SO_2 atmosphere

239 Molecular spatial distributions observed in comet Hale-Bopp with IRAM Plateau de Bure Interferometer

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Millimeter interferometry enables to study the spatial distribution of molecules in inner cometary atmospheres. In March 1997, with the IRAM Plateau de Bure Interferometer, unique data were obtained in comet C/1995 O1 (Hale-Bopp) with angular resolutions of 1 to 3". We have developed a model which simulates interferometric observations of the observed spectral lines. This model takes into account optical depth effects, found to be significant in comet Hale-Bopp. It can accommodate any 3-D molecular spatial distribution. We present here the analysis of the observed CO coma structure using physical models and that of CS, H_2S and SO radial distributions assuming an isotropic outflow. The traditionnal (non gas dynamical) analysis of CO observations suggested the presence of a nearly equatorial CO jet spiraling with nucleus rotation and comprising about 40% the total CO production (Henry et al. 2002). Rodionov and Crifo (2004) developed a time-dependent 3-D model of comet Hale-Bopp gas coma. They investigated first the case of a homogeneous outgassing of CO and H_2O from a non-spherical rotating nucleus. A second computation assumes the presence of an area with increased CO production on the nucleus surface. We show that the structures created in the first case cannot explain the observations while those detected in the second case are comparable to observed ones. The study of the radial distribution of molecular species can provide constraints on their photodissociation rate, and, for radicals, on that of their parents. These rates are not well known for several species and we present results obtained for CS, SO and SO_2.

240 Measurements of zonal winds on Titan with mm Interferometry: From IRAM PdB to ALMA

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We report Titans's observations with the IRAM Plateau de Bure Interferometer, between 2003 and 2005. Spectral maps were obtained in the HC_3N(25-24) and CH_3CN(12-11) rotational lines at 227.4 GHz and 220.7 GHz, respectively. An angular resolution of 0.6 arcsec was obtained using the most extended configuration of the six-antenna array, while Titan's apparent diameter was about 1.0 arcsec. These disk-resolved investigation of the Doppler lineshifts, yield to characterize the zonal wind flow in the upper atmosphere. A clear prograde wind direction is determined at the altitude probed (250 and 400 km), through Doppler lineshifts measurements between the east and west. At the altitude of 400 km, is the first direct determination of the mesospheric wind speed. The retrieved zonal wind speeds will be presented. Simulations of expected wind measurements with ALMA in order to measure wind's variations with latitudes will also be shown.

241 Wide survey of circumstellar envelopes of AGB and early post-AGB stars from ^{12}CO $J=2-1$ and $1-0$ mappings

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Javier Alcolea, OAN, Valentin Bujarrabal, OAN, Michael Grewing, IRAM, Michael Lindqvist, OSO, Robert Lucas, IRAM, Roberto Neri, IRAM, Hans Olofsson, SO, Guillermo Quintana-Lacaci, OAN, Fredrik Shoier, SO, J.M. Winters

A systematic study on circumstellar envelopes (CSEs) of evolved stars is being carried out with the IRAM Plateau de Bure interferometer and the Pico Veleta 30m telescope. We are mapping with resolutions down to $1''$ and $3''$ respectively the ^{12}CO J=2-1 (230 GHz) and 1-0 (115GHz) emission, in envelopes around 37 AGB and 9 early post-AGB stars, selected to cover a large variety of these objects in chemistry, variability types, etc. From our first results we find an astounding large diversity of circumstellar characteristics. In some CSEs (e.g. V Cyg) we have found brightness distributions that are approximately circularly symmetric and with a smooth variation of the brightness with the radius. There are however several other (e.g. RX Boo, IRAS21282+5050 and V Hya) presenting various axisymmetric distributions, either in their very inner CSE regions or/and in their overall envelopes. Variety in the kinematics, mass-loss rates and temperatures have been also found. This survey will provide the basis for future high-resolution observations with ALMA on these extended sources. With ALMA we will have access to the innermost layers of the AGB and early post-AGB CSEs, not yet reachable with the current telescopes. We expect to find the clues to understand the mechanisms responsible for the ejection of the AGB winds and for the emerging fast, collimated, post-AGB winds. Mapping of higher excitation lines with high spatial resolution will likely become the key strategy to tackle this research.

242 Structure, kinematics and chemistry of circumstellar envelopes around the yellow hypergiants stars AFGL 2343 and IRC +10420.

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Yellow hypergiants (YHGs) are amongst the most luminous and massive stars in the sky ($5.3 < logL/L_{sun} < 5.9, \sim 20M_{\rm sun}$). Its evolution is still poorly understood. Only two YHGs, AFGL 2343 and IRC +10420, show a heavy circumstellar envelope. We have observed several molecular transitions and obtained interferometric CO maps complemented with short spacing data of these sources, which together allow us to determine the structure, the kinematics, and the molecular abundances in them. We have used a detail model of excitation and line emission to analyze our maps. We find that the envelopes consist in detached shells expanding at very high velocity, formed during phases of high mass loss ($3\,10^{-4} - 2\,10^{-3}$ $M_{\rm sun}$/yr) lasting typically ~ 1000 yr. However, since some features found in the envelopes are smaller than the size of the beam, a higher spacial resolution is still necessary. A chemistry similar to O-rich AGBs is found in these objects, except for a general subabundance (by about a factor 10) found in AFGL 2343 for other species than CO.

243 Magnetic field in AGB stars and (proto-) Planetary Nebulae : results and perspectives

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During its quick transition to the Planetary Nebula (PN), the Asymptotic Giant Branch (AGB) star will completely change its geometry. On the basis of mm-line observations and existing theories (SiO maser polarization and Zeeman interpretation) we argue that the magnetic filed plays a significant role in the (re)shaping of the AGB envelopes. In order to obtain an unbiased view of the magnetic field in both O- and C-rich stars and their transitions to the proto-PN and PN stages we have used (and will use) the most recent version of the polarimeter installed at the IRAM 30-m toward a representative sample of late-type stars. We have observed the complete polarization pattern of the SiO maser emission from tens of O-rich stars and interpreted the data in terms of the magnetic field strength to show that the field is around a few Gauss and hence could play the role of a collimating, or more generally, of a shaping agent in evolved objects (Herpin et al. 2006). Using the IRAM 'Xpol' instrument, we propose to investigate the Zeeman effect in the hyperfine lines of the CN, N=1-0 transition toward C-rich AGB stars and proto-PN or PN objects with known CN emission. Our analysis will follow closely that used by Crutcher et al (1996) in his CN observations of the interstellar medium. The huge ALMA sensitivity will allow us to extend the magnetic field study to hundreds of evolved galactic stars and perhaps to achieve relative field mapping of the brightest sources.

244 High-J $v = 0$ SiS Maser Emission in IRC+10216: A New Case of Infrared Overlaps

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Maser emission is usually observed towards circumstellar envelopes (CSEs) of AGB stars. In O-rich stars, SiO displays strong maser emission within several vibrational levels from the innermost CSE [1,2]. In C-rich stars only HCN shows this behavior with high intensity [3], although SiS is found to exhibit weak maser emission in the $v = 0$, $J = 1-0$ transition [4]. We report on the first detection of maser emission in the $J = 11-10$, $J = 14-13$ and $J = 15-14$ transitions of the $v = 0$ vibrational state of SiS toward the C-rich star IRC+10216. Transitions $J = 14-13$ and $J = 15-14$ were previously observed but no maser emission was found [5]. These masers seem to be produced in the very inhomogeneous region between the star and the inner dust formation zone, placed at $\simeq 5-7$ R_*, with expansion velocities below 10 km s^{-1}. We interpret the pumping mechanism as due to overlaps between $v = 1-0$ ro-vibrational lines of SiS and mid-IR lines of C_2H_2, HCN and their ^{13}C isotopologues, as were done with several masers showed by SiO [6]. The large number of overlaps found suggests the existence of strong masers for high-J $v = 0$ and $v = 1$ SiS transitions, located in the submillimeter range. In addition, it could be possible to find several rotational lines of the SiS isotopologues displaying maser emission. REFERENCES [1] Cernicharo, J. et al., 1993, ApJ, 407, L33 [2] Pardo, J. R. et al., 1998, A&A, 329, 219 [3] Schilke, P. & Menten, K. M., 2003, ApJ, 583, 446 [4] Henkel, C. et al., 1983, ApJ, 267, 184 [5] Sahai, R. et al., 1984, ApJ, 284, 144 [6] Cernicharo, J. et al., 1991, A&A, 249, L27

245 Winds of massive hot stars

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Recent studies point towards the strong presence of clumping in the winds of massive stars. If confirmed, mass-loss rates of these objects during their life time should be dramatically revised downward,s with crucial implications on the evolution of these objects. The FAR IR and millimeter region, which will covered by ALMA, provides a unique window to infer the behavior of clumping in the stellar winds of massive hot stars. Further, the enormous gain in sensitivity provided by ALMA will increase by roughly a factor of 1000 the number of massive hot stars available for studies of their stellar winds.

246 The Massive Expanding Torus in the Planetary Nebula NGC 6302

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The planetary nebula NGC 6302 has a bipolar, ‘butterfly’ outflow, with the exciting star at its centre obscured by an absorption lane seen in Hα, suggestive of a circumstellar torus. We have recently imaged the NGC 6302 PN with the JCMT and Submillimeter Array (SMA) in the 230 GHz continuum as well as the ^{12}CO(2-1), ^{13}CO(2-1), ^{12}CO(3-2) and ^{13}CO(3-2) lines. In distinct contrast to observations of PPN, whose CO emission are typically dominated by outflow, only a minor component of the CO emission from NGC 6302 appears associated with the outflow from this source. Our study reveals that the bulk of the CO traces a massive, i.e. ~ 1.4M$_\odot$, expanding torus around the central star. An intermediate velocity component of the ^{12}CO and ^{13}CO emission coincides with the dark absorption lane seen in the Hα image of the source and corresponds to the near side of the torus. The high mass of the torus combined with estimates for the mass of the other components in the system suggest that the progenitor of this system had an initial mass of > 3M$_\odot$. The torus is in fast expansion, with V$_{exp} \sim 10$ km.s^{-1}. Given the size of the torus, this implies a dynamical age of the torus of ~ 6300 yr. The presence of an inner edge to the torus suggests that this mass loss ceased ~ 2400 yr ago. These values suggest a mass loss rate of $> 3 \times 10^{-4}$M$_\odot$/yr while the torus was formed. The extreme mass of the NGC 6302 molecular content reported here raises new important issues concerning PPN and PN evolution.

247 HCN and SiO maser emission in Carbon and Oxygen AGB stars

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We present the results derived from the monitoring of the HCN maser emission in a sample of C-rich AGB stars using the 30m telescope Pico de Veleta, as well as the VLBA maps of the circumstellar SiO masers in the O-rich variable R Cas. The HCN emission shows a strong variability, changes of about 50% in the peak flux have been measured in some cases. On the other hand, the spatial distribution of the SiO maser emission in R Cas is compatible with previous observations in oxygen-rich envelopes.

248 Large-scale molecular shocks in starburst galaxies

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Large-scale molecular shocks may arise at different times and locations during a starburst episode. Density waves in the pre-starburst phase, bipolar outflows at the onset of star formation and gas outflows in the superwind stage may drive shocks as the starburst evolves. We have carried out high-resolution ($\sim 5''$) images of the emission of silicon monoxide (SiO) in the nuclei of the nearby star-forming galaxies M82, NGC253 and IC342 with the IRAM Plateau de Bure Interferometer (PdBI). From observations in the Galaxy and theoretical models, SiO is known to be a privileged tracer of molecular shock chemistry. In the three surveyed galaxies widespread SiO emission is found along several hundreds of pc and large SiO abundances, $< X(SiO) > \sim 10^{-9}$, are inferred. These results show that large-scale shock chemistry must be at play in the inner 1 kpc disks of these galaxies. Noticeable differences in the morphology of the SiO emission call to different driving mechanisms, however. In NGC253 and IC342, the most plausible scenario is that of shocks arising in cloud-cloud collisions, dynamically triggered along the bar potential. In the case of M82, shocks arise in the disk-halo interface, likely boosted by local episodes of mass injection from the disk. Such differences reflect the evolutionary stage of the starburst episodes. Follow-up images of the emission of other shock tracers, like methanol (CH_3OH) and sulfur monoxide (SO), may help us to quantify the masses and energies involved in shock events. This work illustrates how high-resolution imaging of specific chemical tracers can provide useful inputs to the understanding of galaxy evolution.

249 In the search for CO emission in young, low-metallicity spiral disks and dwarf galaxies: Prospects for ALMA

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We present the results of the search for ^{12}CO emission in IZw18, the lowest metallicity galaxy known to date, and the also metal poor extended UV disk of NGC4625, as the best local counterpart to the distant young spiral disks, using the IRAM 30m-MRT. The conclusions from this study are used to analyze the prospects for the detection with ALMA of these objects at intermediate and high-redshift, where they are thought to be a major contributor to the population of galaxies.

250 CO Survey of Edge-on, Late-type Galaxies

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We present preliminary observations from a study of CO in nearby, edge-on, late-type galaxies using the CARMA interferometer. Our program is designed to explore how the content and distribution of CO in these systems changes as a function of V_{rot}, various optical and HI properties, and the presence and structure of dust lanes. In addition, we plan to compare our results to previous studies, which found that the existence of observable dust lanes in edge-on galaxies depend strongly on V_{rot} and other physical parameters. The high sensitivity and dynamic range of ALMA will be optimal for large galaxy surveys of this kind.

251 Results from the Spitzer Survey of the Small Magellanic Cloud: fertile ground for ALMA

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I will present and discuss recent results of the Spitzer Survey of the Small Magellanic Cloud (S3MC) and outline future ALMA follow up observations. The S3MC program imaged the SMC in all the Spitzer wavebands, obtaining superb data and breathtaking images in the mid and far infrared at 0.6 to 12 pc resolution. These data allow us to study in unprecedented detail the nearest example of a "primitive" galaxy, with peculiar dust properties and active star formation. We identify approximately 300 bright YSOs throughout the SMC in the midIR that correspond to late Class 0 to Class II sources, with a similar number of candidate early Class 0 sources identified using the 24 and 70 μm data. We find values of the [8]/[24] band ratio (a measure PAH abundance) that span from 1 (typical of high metallicity environments) to 0.1 (low metallicity), showing that the grain properties exhibit strong local variations related to the ISRF. We analyze the resolved FIR emission and use it to measure the surface density of molecular gas. Almost half of the H2 in SMC clouds lies along lines of sight without detected CO emission (I(CO)$< 0.35 K$km s^{-1}). SMC molecular clouds also have lower mean extinction than those in the Milky Way (only about 2 magnitudes on average), and surface densities of gas that are only moderately higher than those of Milky Way GMCs, in contrast to predictions from the theory of photoionization regulated star fomation. The S3MC survey provides fertile ground for future ALMA high resolution observations of an environment very different from our own.

252 High-resolution observations of high-mass protostars in Cygnus X

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Since high-mass protostars are extremely rare, the best candidates to be collapsing precursors of OB stars are located at several kpc from Sun. The general lack of spatial resolution in the far-IR to millimeter range is a significant weakness for observational works in this field. ALMA will be crucial for these studies, and will open the field by fully resolving individual objects all over the galactic plane. Using currently available interferometers, it is already possible to resolve the most nearby high-mass protostars and to obtain a first flavour of what ALMA will achieve for the whole Galaxy. We will present our recent observations with the IRAM PdBI for 12 high-mass protostars in Cygnus X (1.7 kpc) at a 1$''$ spatial resolution at 1.3 mm. This sample has been obtained from an unbiased survey of the whole Cygnus X complex (Motte et al. 2006) and is thus representative. These observations resolved the individual objects in dust continuum and molecular lines (CO, SiO and $H^{13}CO^+$) and clearly demonstrate that the objects are sub-fragmented (mostly double) at rather small physical sizes of only $\sim$ 4000 au. Jet-like CO outflows are also detected. This work allows us to build the first representative evolutionary diagrams (envelope mass versus luminosity, and outflow power) for individual high-mass protostars to be compared with theoretical tracks.

253 Star formation properties of the merging galaxy cluster Abell 3921

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We present a combined optical and radio analysis of the merging galaxy cluster Abell 3921, with the main purpose of understanding if and how the merging process affects the star-formation history of galaxies in clusters. The SF properties of the confirmed cluster members in the central field of A3921 have been investigated by comparing: a) their spectral features and colour properties (EFOSC2 and WFI observations), and b) their radio luminosities at 1.344 GHz derived from our new ATCA observations. Emission-line galaxies are spatially concentrated in the collision region of the two subclusters, and they are forming stars at low rates (<3.7 M_{odot}/yr). We therefore suggest that most of the detected star-forming objects of A3921 are not infalling, gas-rich field galaxies, seen in projection in the collision region. They are most likely located between the two interacting sub-clusters, and their ongoing SF could have been refuelled by the cluster merger.

254 SMA CO(2-1) imaging of the dust lane and circumnuclear gas in Centaurus A

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At a distance of $D \sim 3.5$ Mpc, Centaurus A (NGC 5128, CenA) is by far the nearest active radio galaxy. The center of this galaxy, within a few hundred parsecs of the nucleus, is very complex. At mm/submm wavelengths, three main components can be distinguished: a sub-pc nucleus hosting a massive object, a region of circumnuclear gas and dust, and absorption by gas in the dust lane along the line of sight to the core. Several atomic and molecular lines have been observed in emission and absorption toward the center of CenA, but no high angular resolution study of the warm and dense molecular gas has been completed so far. Here we present CO(2-1) images of CenA made with $2 \times 6''$(70 $\times$ 210 pc) resolution using the SubMillimeter Array interferometer (SMA). These observations allow us to distinguish the distribution and kinematics of the different components with unprecedented detail, as well as the distribution and optical depth of the CO absorption.

255 Search for galactic X-ray Dominated Regions

Frédéric Boone, Observatoire de Paris,
Santiago Garcia-Burillo, OAN Madrid, Jesus Martin-Pintado, CSIC Madrid, Antonio Usero, OAN Madrid, Sergio Martin, CfA Cambridge, Asuncion Fuente, OAN Madrid, Susanne Huettemeister, Universitaet Bochum

Recent observations suggest a peculiar chemistry of the ISM in X-ray dominated regions. With the help of high resolution millimeter instruments like the ALMA the chemistry of the ISM might become an essential diagnosis tool for the study of nuclear activity in nearby galaxies: the X-ray radiation of the nucleus could determine the chemistry at the scale of hundreds of parsecs. In order to improve the phenomenological basis for the models and the interpretation of extragalactic observations we started multiline observations of a sample of galactic High Mass X-ray Binaries. These are strong hard X-ray emitters and are the closest analogues to AGN at the stellar scale. Though X-ray spectroscopy can give a hint on the column densities and these object are young molecular gas is not necessarily associated. The first step is therefore to identify molecular gas in the vicinity. γ,Cas, 2S 0114+650 and a region 1″ SE from CI Cam were observed with the 30 m telecope in the CO(1–0) and CO(2–1) lines. These observations associated with the observation of absorption lines in the optical domain found in the litterarure allow us to discuss the presence of molecular gas close to the X-ray emitters for further studies.

256 Submm CO lines as tracers of star formation in galaxies

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The ground state CO rotational line, CO($J1 \rightarrow 0$) has been used, as a tracer for molecular gas in galaxies for more than 20 years. Emission in higher J CO transitions is more sensitive to the presence of dense and warm gas than the ground state line. In this presentation, we discuss our survey of the submillimeter lines of C and CO in galaxies, and compare the submillimeter C and CO line emission with the far infrared continuum and line emission. We show that the CO cooling rate defined as the total power radiated by CO, is linearly correlated with the far infrared luminosity in the galaxy nuclei we studied. The C and CO cooling rates can also be used as diagnostics of the galaxy properties as the shape of the CO SED, together with the CO contribution to the total gas cooling rate, and the ratio of CO and C cooling power, depend on the star forming activity in galaxies. While these conclusions are based on single dish observations, the morphology of the submm C and CO emission, which will be provided with ALMA, will reveal the location of the embedded star forming clusters and will allow an accurate comparison of star forming gas in galaxy nuclei and disks.

257 Millimeter VLBI detection of the TeV blazar Markarian 501

Marcello Giroletti, INAF Istituto di Radioastronomia, Bologna, Italy

Very few blazars have been detected with mm-VLBI to date. We report on observations of the TeV blazar Mrk 501 using the Global mm-VLBI Array at 86 GHz. A 130 mJy compact component is detected on the baselines between Effelsberg, Pico Veleta, and Plateau de Bure. This discovery has important bearings on both current science and future technology. It provides information on the physics of the radio core of this blazar on scales of a few 100's Schwarzschild radii; moreover, it is a promising starting point for further improvements at higher frequencies and lower flux densities: when new facilities such as ALMA are included in existing VLBI arrays, the region of the jet formation will become observable in a large number of blazars.

258 Radio continuum and HI study of gas-loss processes in nearby galaxies.

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Physical properties of galaxies change with cosmic epoch and also as they 'age'. One of the prominent contributions towards this change would be from the gas-loss processes going on in these galaxies. We have studied a number of galaxies in radio continuum and HI using both the VLA and the GMRT where different components of the interstellar medium are displaced or pushed outwards due to such gas-loss processes like starburst-driven superwinds, AGN-driven outflows, ram pressure stripping and tidal interactions. We have found HI outflow possibly associated with the molecular, ionised and synchrotron plasma outflow in NGC6764. Kinematic effects on the HI gas have also been seen in the archetypal superwind galaxy NGC1482. In the disturbed Virgo cluster galaxy NGC4438, where the molecular gas is also displaced on the western side along with other ISM components, we have made a detailed study of the distribution and kinematics of the HI gas. This galaxy may be affected by both tidal interaction and ram pressure due to the ICM. In galaxies in the cluster Abell 1367 long tails extending from 50 to 75 kpc are known in radio continuum and Halpha due to ram pressure of the ICM. Here again we have made a detailed study of the atomic HI gas. In this paper we summarise the results of our study, discuss the importance of studying such systems at mm wavelengths over a range of redshifts and explore the possibility of pursing such a study with ALMA. It is worth noting that only in very few galaxies molecular gas has been detected either as the entrained gas in the outflow or as displaced gas from the disk of the galaxy, primarily due to lack of sensitivity and resolution.

259 The Spitzer Wide-area Infrared Extragalactic Survey (SWIRE) and ALMA

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Carol Lonsdale, Caltech, Michael Rowan-Robinson, Imperial College London, and the SWIRE team

The Spitzer Wide-area Infrared Extragalactic Survey (SWIRE, Lonsdale et al. 2003), the largest of the Spitzer Legacy extragalactic surveys, has observed 50 square degrees in six areas of the sky with the Spitzer IRAC and MIPS cameras in seven infrared bands as well as in several optical bands from the ground. The SWIRE fields are the best regions of the sky for Far-infrared and submm observations due to the low background emission. SWIRE has detected over 2 million infrared extragalactic objects, with a large fraction detected in the far infrared and at high redshift. Many of these sources are ideal targets to follow-up with ALMA. We describe the SWIRE database of images and multi-band object catalogs, and the main scientific results obtained so far by the SWIRE team.

260 Studying galaxy clusters with ALMA.

Jose M. Diego, IFCA

We show some examples of expected results obtained when ALMA looks at distant galaxy clusters. In addition to the well known Sunyaev-Zelovich effect we expect to see second order effects. These effects include lensing of background sources and the Vishniac effect, determination of the bulk motion along the line of sight and polarization of the cosmic microwave background.

261 Survey of Molecular Clouds in the Magellanic Clouds by NANTEN; Properties of the Molecular Clouds and Star Formation

Akiko Kawamura, Nagoya University,
Toshikazu Onishi, Nagoya University, Norikazu Mizuno, Nagoya University, Yoji Mizuno, Nagoya University, Tetsuhiro Minamidani, Nagoya Universtiy, Yasuo Fukui, Nagoya Universtiy, Akira Mizuno, Nagoya University

High mass stars and massive clusters characterize star formation activity in galactic scales; massive stars have substantial effects on triggering further star formation from at their early stages to at the end stages. The Large and Small Magellanic Clouds (LMC and SMC) make us possible to study how the interstellar medium evolves and how stars are formed in detail because of their proximity to us. Its favourable viewing angle also let us study the properties of the molecular clouds and star formation activity without contamination along the line of sight especially for the LMC. We have made large-scale surveys of the molecular clouds in the Magellanic Clouds by NANTEN at Las Campanas Observatory in Chile. The surveys gave us a complete set of about 300 molecular clouds with an angular resolution as high as about 40 pc. The GMC dataset includes those with different star formation activities through out the galaxies. Large-scale surveys in H alpha and HI emissions have revealed a number of supershells in the LMC (e.g., Meaburn 1980). Optical, Infrared and Radio continuum observations have been indicating large samples of formation sites of stars or clusters. We will present the properties of the molecular clouds obtained from our CO surveys and star formation activities from a comparison with the resent infrared surveys.

262 Gas Dynamics and Star Formation in Galaxies

Jin Koda, Caltech

Despite numerous observational and theoretical studies, the nature of interstellar medium (ISM) gas dynamics remains uncertain. The dynamical response of the gas depends significantly on whether the ISM is a continuous hydrodynamic fluid or a set of discrete molecular clouds. The hydrodynamic fluid produces shocks along spiral arms or bars in galaxies, while the molecular clouds could ballistically pass the spiral/bar structures without encountering a shock. Such differences must change not only the dynamical response of the gas (e.g. shock, dissipation), but also the evolution timescale (e.g. gas inflow) and star formation. There is a general belief that only continuous hydrodynamic models could reproduce the narrow gas/dust lanes observed in barred galaxies. Based on CO interferometer observations, we, however, demonstrate that the cloud-based gas dynamics can also reproduce the offset ridges and star formation in barred galaxies. ALMA will resolve the structure of the gas in galaxies, probing the gas dynamics, evolution timescale of galactic disks, and star formation.

263 Buried AGNs in ultraluminous infrared galaxies

Kotaro Kohno, Masatoshi Imanishi, Kouichiro Nakanishi

Distinguishing whether the extremely dust enshrouded energy sources of ultraluminous infrared galaxies (ULIRGs) are starbursts or AGNs is important for understanding the obscured AGN-starburst connections in the universe. Using the Nobeyama Millimeter Array (NMA), we measured the HCN-to-HCO+ brightness temperature ratios of 10 ULIRGs nuclei, to disentangle XDRs (around a luminous X-ray emitting buried AGN) from PDRs (around strongly UV emitting starbursts). We found that ULIRGs diagnosed to be AGN- (starburst-) powered from our infrared spectroscopy distribute in an XDR (PDR) range, as expected. Since dust extinction is negligible in the (sub-)mm wavelength range, this method can be effective to systematically unveil the nature of dust enshrouded energy sources of ULIRGs from low- to high-z universe in the ALMA era. Interferometry is crucial to pinpoint ULIRGs' nuclei and find XDRs signatures there, by minimizing the contamination from extended star-formation emission in host galaxies. Our first results have been published as Imanishi et al. (2006 AJ 131 2888).

264 Molecular gas in the most isolated galaxies

Lourdes Verdes-Montenegro, Instituto de Astrofísica de Andalucía ,
AMIGA team

A long-standing question in galaxy evolution involves the role of nature (self-regulation) vs nurture (environment) on the observed properties (and evolution) of galaxies. A collaboration centered at the Instituto de Astrofisica de Andalucia (Granada, Spain) is trying to address this question by producing a observational database for a sample of 1050 isolated galaxies from the catalogue of Karachentseva (1973) with the overarching goal being the generation of a "zero-point' sample against which effects of environment on galaxies can be assessed. The AMIGA (Analysis of the Interstellar Medium of Isolated Galaxies) database (see www.iaa.es/AMIGA.html) will include optical, IR and radio line and continuum measures. The galaxies in the sample represent the most isolated galaxies in the local universe. We observed the CO content of 182 of these galaxies in a velocity restricted subsample (velocities between 1500 and 5000 km s^{-1}), mainly with the IRAM 30m telescope and the FCRAO 14m telescope. Together with data from the literature, we have data for the CO emission of 204 isolated galaxies in this velocity range. I will present the results of this study and will outline how ALMA can improve our understanding.

265 Molecular Gas in Radio Galaxies with New and Re-started Activity

Karl-Heinz Mack, IRA-INAF Bologna,
Lakshmi Saripalli, RRI Bangalore, Ignas Snellen, U Leiden, Richard Schilizzi, Int SKA Off Dwingeloo, Ravi Subrahmanyan, RRI Bangalore

The fuel in active galaxies is believed to be primarily in the form of molecular gas. Radio galaxies are found to possess larger quantities of molecular gas than radio quiet elliptical galaxies. Searches for molecular gas at the centres of powerful radio galaxies have yielded surprising results: (1) notwithstanding their requirement of large amounts of fuel, not all are detected in CO, and (2) among those detected there is a virtual monopoly of radio galaxies having compact structures and lower radio power. We have started a systematic search for CO in two representative and complementary samples of radio galaxies in which the question of fueling plays an important role. The first sample is composed of nearby young radio galaxies at the beginning of their evolution, the second sample comprises recurrent radio galaxies, i.e. older sources which have recently started a new phase of activity. We show first results of the observations and discuss the impact of ALMA on this kind of research.

266 A multi-transition study of HCN and HCO$^+$ in active galaxies: Starburst versus AGN environments

Melanie Krips, Harvard-Smithsonian Center for Astrophysics,
Roberto Neri, IRAM , Santiago Garcia-Burillo, OAN, Francoise Combes, LERMA, Sergio Martin, Harvard-Smithsonian Center for Astrophysics

Over the past decade, several studies have indicated that not only can the HCN-to-CO and HCN-to-HCO$^+$ intensity ratios be significantly increased in active galaxies compared to non-active galaxies but the degree of their increase also appears to depend on the type of activity, i.e., whether a starburst (SB) or an AGN is the dominant active source. The increase and its degree can have various origins, such as systematically different densities, temperatures, abundances, and/or additional non-collisional excitation of the gas. We thus carried out IRAM 30m observations of several HCN and HCO$^+$ transitions in 12 nearby active galaxies to analyse their gas properties as a function of the activity type. The starburst dominated sources in our sample clearly tend to have systematically higher HCN(2-1)/(1-0), HCN(3-2)/(1-0) and HCO$^+$(3-2)/(1-0) intensity ratios than the "pure AGN" ones. An LVG analysis suggests that the cause of the different ratios is a combination of slightly higher gas densities and temperatures in SB and a non-standard HCN abundance in AGN environments. However, some of the sources exhibit an AGN and SB activity on scales smaller than the 30m beam size representing an important caveat for the analysis. We thus started follow-up observations of HCN and HCO$^+$ at the SMA and IRAM PdBI of a few selected sources to better separate the different activity regions and estimate their respective contribution to the Single Dish data. First results will be discussed for the HCN emission in NGC 1068 and NGC 6951 revealing also important new information on the gas properties in addition to those already gained via CO.

267 The evolution of galaxies from primeval irregulars to present-day ellipticals

Masao Mori, Senshu University,
Masayuki Umemura, Tsukuba University

High redshift Lyman-α emitters (LAEs) and Lyman break galaxies (LBGs) possibly provide a significant key for the embryology of galaxies. LBGs have been argued as candidate progenitors of present-day elliptical galaxies in terms of their observed properties. But, what evolutionary stages LBGs correspond to and how they are related to LAEs are still under debate. Here, we present an ultra-high-resolution hydrodynamic simulation on galaxy formation. We show that, at the earliest stages of less than 3×10^8 years, continual supernova explosions produce multitudinous hot bubbles and cooled HI shells in-between. The HI shells radiate intense Lyman-α emission like LAEs. After 10^9 years, the galaxy emission is dominated by stellar continuum, exhibiting LBG-like spectrum. Also, we find that, as a result of purely dynamical evolution over 13 billion years, the properties of this galaxy match those of present-day elliptical galaxies well. It is implied that the major episode of star formation and chemical enrichment in elliptical galaxies is almost completed in the evolutionary path from LAEs to LBGs.

268 A multi-transition CO and HCN line survey of Luminous Infrared Galaxies

Padelis P. Papadopoulos, ETH, Zurich

First results from a large CO, 13CO and HCN multi-transition survey of 30 Luminous Infared Galaxies ($L_{fir} > 10^1 1 L_{\odot}$), with data for the CO J=1-0 up to J=4-3, 13CO J=1-0, 2-1, and HCN J=1-0, 3-2, and 4-3 lines will be presented. These suggest a wide range of conditions for galaxies with otherwise similar FIR and CO, HCN J=1-0 line luminosities. Spectral line SEDs for the ULIRGs Arp 220, Arp 193, NGC 6240 and Mrk 231 are constructed for the CO and HCN rotational transitions, and used to: a) find the conditions of the dense molecular gas fuelling their spectacular starbursts, b) interpret the sparse CO and HCN lines detected from starbursts at high redshifts.

269 Spectral Energy Distribution of Normal Galaxies

J. Masegosa,
I. Márquez, B. Rocca-Volmerange

The Spectral Energy Distribution (SED) from Optical to Far IR frequencies of normal galaxies is presented. A sample of 131 galaxies has been obtained that follows the normal galaxy criterium based on IRAS colors as defined in Masegosa et al (2005). A comparison with PEGASE.3 models is also shown. A full discussion is made on the validity of these models for describing galaxies in the local Universe and the implications for the analysis of high redshift objects.

270 A molecular gas study in low-luminosity radio galaxies

I. Prandoni, INAF - Istituto di Radioastronomia

We discuss CO spectral line data of a volume-limited sample of 23 nearby ($z<0.03$) low luminosity radio galaxies, selected from the B2 catalogue. We investigate whether the CO properties of our sample are correlated with the properties of the host galaxy, and in particular with the dust component. We find strong evidences for a physical link between the dust disks probed by HST in the galaxy cores and the molecular gas probed by the CO spectral lines, which in two cases display a double-horn shape, consistent with ordered rotation. On the other hand, from a preliminary comparison with other samples of radio sources we find no significant differences in molecular gas properties between FRI and FRII radio sources. In order to confirm the suggestion that the CO is dynamically associated with the core dust disks, the most suitable sources of our sample will be proposed for interferometric imaging at PdBI.

271 Chemistry and excitation of the deeply obscured LIR Galaxy NGC4418

Raquel Monje, Onsala Space Observatory,
Susanne Aalto, Onsala Space Observatory, Martina Wiedner, Physikalische Institut, Christophe Risacher, European Southern Observatory

We present recent IRAM 30m and APEX data on the deeply dust-enshrouded interacting galaxy NGC 4418. NGC 4418 is suspected to harbour an embedded AGN and has a surprisingly rich ISM chemistry. We will present a sample model of the properties of the interstellar medium of NGC 4418.

272 Dense Clouds and Star formation on Spiral Arm in M33 -deep CO and HCN observation in NGC604-

Rie Miura, University of Tokyo/NAOJ,
Yoichi Tamura, University of Tokyo/NAOJ, Sachiko K. Okumura, NAOJ, Ryohei Kawabe, NAOJ, Tomoka Tosaki, NAOJ, Nario Kuno, NAOJ, Kouichiro Nakinishi, NAOJ, Seiichi Sakamoto, NAOJ, Takashi Hasegawa

We investigate the properties of giant molecular clouds (GMCs) in the massive star forming region NGC604 on the spiral arm in M33. We observed CO(J=1-0), HCN emission and 90GHz continuum using Nobeyama Millimeter Array. Our objective is to find observational constrains for the process of the gas through the spiral shock to form stars and this time we will discuss the properties of clouds on spiral arm. High resolution CO map make it possible to decompose the CO emissions into 10 resolved clouds with masses of $0.1 - 2.3 \times 10^5 M_\odot$ and size of 18-30pc. We could detect HCN emissions with 4 sigma at the two massive clouds which are found a couple of the smaller clouds. 90GHz continuum is also detected at the portion of the HII emitting area. Thus, we could classify the 10 clouds into 4 categories; the clouds show (1) no sign of star formation (2) sign of dense gas formation but no HII region, (3) association with both dense gas and star cluster formation, and (4) associated only with HII region.

273 Resolving Nuclear Gas Disks in CO at 0.3” (<10pc) resolution

Eva Schinnerer, MPIA

We present highest (0.35”-0.6”) angular resolution observations of the molecular gas in the central 100 parsecs of the two late type galaxies IC342 and NGC6946 obtained with the IRAM PdB interferometer in its largest new A+ configuration. Both galaxies exhibit abundant dense molecular material close to their very centers. Analysis of the CO(2-1) gas kinematics with sub-10pc resolution reveals evidence for gas flow towards the central nuclear gas reservoir where the central starburst is occuring. This indicates that repetative central massive star formation can also be maintained in the future. These highest resolution observations, the first obtained with the new long baselines at Plateau de Bure, demonstrate the capabilities of ALMA where $0.3''$ resolution will be achieved routinely.

274 Molecular Clouds and Star Formation in Barred Spiral Galaxies

Kazuo Sorai, Hokkaido University,
Nario Kuno, Nobeyama Radio Observatory, Naomasa Nakai, Tsukuba University, Yoshimasa Watanabe, Hokkaido University, Hidenori Matsui, Hokkaido University, Asao Habe, Hokkaido University,

Barred spiral galaxies are good laboratories to study how star formation is affected by global kinematics of molecular gas. Several previous studies have indicated that intense gas motion suppresses star formation in bars. Our CO survey program with the Nobeyama 45-m telescope (the Nobeyama CO Atlas) has revealed several characters of distribution and kinematics of molecular gas in barred spiral galaxies. Maffei 2 is one of them, which shows abrupt velocity changes in position - velocity diagrams and wide velocity width in the bar, which suggests properties of molecular gas differ from that in spiral arms. Observations with the Nobeyama Millimeter Array resolve partially the wide velocity components to several ones, molecular gas rushing into the bar and moving along the leading edges. However, observations with higher spatial resolution and sensitivity is essential to reveal how global motion of molecular gas have influence on star formation in bars. Observations of CO lines with the Atacama Large Millimeter Array will resolve molecular clouds in nearby galaxies. Hence, we will be able to deduce detail kinematics and density of molecular clouds, which will clear the issue.

275 Detection of Cosmic Microwave Background lensing and constraint of dark energy properties

Paola Andreani (ESO, Germany),
Carlo Baccigalupi (SISSA, Trieste, Italy), Viviana Acquaviva (SISSA, Trieste, Italy),

Gravitationally lensed CMB belongs to a class of observable able to constrain the average of the dark energy abundance at the time of equality with matter, occurring at redshift of about 0.5. Indeed, the dark energy abundance at the epoch influences directly the lensing strength, which is injected at about the same time, if the source is the CMB. The detection of this effect provides a unique and an extraordinary tool to directly measure the expansion acceleration of the Universe. We discuss the potentiality of ALMA in providing with such fundamental observable and how ALMA may carry out such observations.

276 Rapid star formation in the presence of AGN: Implications for high-redshift observers

Chris Lintott, University College London,
Serena Viti, University College London

Recent observations reveal galaxies in the early Universe ($2<z<6.4$) with large reservoirs of molecular gas and extreme star formation rates, as determined by infrared luminosities. For a range of sources ranging from Milky Way star forming regions to external galaxies, a tight relationship exists between the infrared luminosity, and the luminosity of the HCN J=1-0 spectral line. Sources at redshifts beyond z 2 do not follow this trend; the deficit in HCN is conventionally explained by an excess of IR radiation due to active galactic nuclei. We adapt models of hot core chemistry and show that the presence of AGN in star-forming sources results not only in an increase in IR luminosity, but also the HCN fractional abundance. As a result the presence of an AGN cannot account for the observed excess of infrared over molecular luminosity. Furthermore, we show that the observed abundance of HCN is in fact consistent with a population of stars forming from near-primordial gas. We also examine the behaviour of other molecules in high ionization environments and suggest future observational strategies for observing high-z starforming galaxies.

277 High Resolution CO(3-2) and HCO+(4-3) Imaging of the Luminous Infrared Galaxy NGC 6240

D. Iono, NAOJ

We present interferometric CO(3-2), HCO+(4-3) and 870 micron continuum images of the luminous infrared galaxy NGC 6240 obtained at the Submillimeter Array (SMA). Our spatially resolved CO (3–2) and HCO+(4-3) emission peaks between the two nuclear components that are known to both harbor AGNs. We analyze the physical properties of the molecular gas in nuclear starburst region using a Large Velocity Gradient (LVG) analysis. The LVG analysis performed on each 50 km/s channel using the CO(3-2), CO(1-0), HCO+(4-3), and HCO+(1-0) data cubes suggests that the peak of the molecular gas emission traced in our observations is warm (T = 20 - 200 K), dense ($n_{\mathrm{H}_2} = 10^{4.5-5.3}$ cm^{-3}) and optically thin ($\tau = 0.01$ - 2) in the densest regions of the central 1 kpc. The average density in the central 2 kpc is $n_{\mathrm{H}_2} \sim 10^{4.0}$ cm^{-3}, and the gas is highly turbulent there ($\Delta v_{\mathrm{FWZI}} \sim 900$km s^{-1}). The derived molecular gas mass in the central 0.5 kpc (1.5×10^9 M$_\odot$) is consistent with the mass derived from previous CO (2–1) observations.

278 High Angular Resolution Imaging of High Redshift Galaxies at 345 GHz

Alison Peck, Harvard-Smithsonian CfA,
Daisuke Iono, NAOJ, Glen Petitpas, Harvard-Smithsonian CfA, and SMA Team

Recent single-dish submillimeter wavelength surveys have revolutionized observational cosmology by uncovering a substantial new population of dust-enshrouded starburst galaxies at high redshift. A tremendous amount can be learned about the star formation history of the universe by comparing the characteristics of these early sources at a range of wavelengths, from radio to x-ray. Unfortunately, the positions of these sources are not well enough determined in the parent surveys to justify devoting large amounts of time using higher resolution instruments without first performing high precision astrometry. The Submillimeter Array on Mauna Kea is now the ideal instrument for this, as it can observe at the same frequency as the original survey, but with substantially better angular resolution, yielding astrometric accuracies of ~100 mas. We present images of the distant galaxies detected to date using the Submillimeter Array at 345 GHz.

279 The Nature of CO Emission in Submillimeter Luminous Galaxies from 2<z<6.4

Desika Narayanan University of Arizona,
Yuexing Li Harvard , Thomas J. Cox Harvard , Lars Hernquist Harvard, Sukanya Chakrabarti Harvard, Romeel Davé University of Arizona, Tiziana Di Matteo Carnegie Mellon , Liang Gao

Recent pioneering CO observations of submillimeter luminous galaxies and AGN from $2 < z < 6.4$ allow us to study coevolution of black hole growth and star formation in galaxies during the heyday of massive galaxy formation. However, little is known concerning the physical nature of these first galaxies, and the relationship between the central AGN, ISM, and host galaxy properties to the observed CO emission. In order to provide a framework for an interpretation of these observations, we investigate the nature of the CO emission in $z > 6$ quasars and $z \sim 2$ submillimeter galaxies by combining a 3D non-LTE radiative transfer code with cosmological and galaxy merger hydrodynamic simulations. Our simulations include star formation, black hole growth and feedback, a multi-phase ISM and winds. We additionally include Giant Molecular Clouds through a subgrid formalism. In our presentation we discuss our model results in terms of predicted CO morphology/excitation, and the potential of using CO line widths as dynamical mass indicators. We will make comparisons with existing observations of high-z systems, and utilize these simulations to describe a self-consistent, physically motivated scenario for the formation and evolution of these crucial galaxies.

280 Near-IR to sub-mm observations of lensed z> 6 galaxies and faint optical drop-outs

Frédéric Boone, Observatoire de Paris

We have undertaken deep optical and near-IR imaging of two strong lensing clusters, which has allowed us to identify 13 star forming galaxy candidates at z ∼6-10 (Richard et al. 2006, A&A in press, [astro-ph/0606134]). Our previous optical and near-IR observations (mostly from WFPC2/HST, CFHT, ISAAC/VLT) have now been complemented by new deep imaging with ACS/HST, with new Chandra observations, and with Spitzer IRAC and MIPS at longer wavelengths. Furthermore we have undertaken ISAAC and FORS2 spectroscopy of a number of the high-z candidates and other interesting objects in the field including possible intermediate-z interlopers. Finally SCUBA data is available for some of the objects, and some new targetted observations, including an established $z \sim 6$ galaxy, have been obtained at IRAM. Based on these multi-wavelengths observations we will present an analysis of the SED of these high-z candidates/objects and discuss their stellar and dust properties. The constraints derived on the star formation history at $z \sim 6-10$ will also be discussed. These results illustrate the interest of lensing cluster observations with future facilities such as APEX, ALMA and HERSCHEL.

281 Radio-FIR photometric selection of high-z galaxies for ALMA

Itziar Aretxaga, David H. Hughes, J.S. Dunlop, et al.

Ground-based submillimetre and millimetre blank-field surveys have identified a few hundred galaxies, the majority of which are believed to be heavily dust-obscured starburst galaxies. Larger numbers of these galaxies still will be discovered in the new generation of (sub-)mm surveys, currently underway. An efficient photometric redshift technique is clearly needed in order to select subsamples of objects that will allow to carry out detailed follow-up experiments to derive the physical and clustering properties of the galaxies and their cosmic evolution. We will describe three different methods that our group has been developing and using to derive photometric redshifts, and their different degrees of success and innherent biases. We present an updated assesment of the accuracy on which radio-mm-FIR photometric redshifts can be obtained in the light of the mounting optical/IR and CO spectroscopic data, which reconfirm that photometric redshifts can indeed be used as a selection technique that will produce samples in redshift bands of $\Delta z \sim \pm 0.3$ to 0.7 (rms in the z-z plot), depending on the combination of currently available photometric bands used within the radio–mm–FIR regime, of more than 3 to only 2, the redshift regime and, ultimately, the true nature of the sub-mm galaxies. These photometric redshift techniques will be of use in combination with the next generation of broad-band receivers, not only to select the samples to target, but to guide the tunning of narrower-band receivers in the cases when the broad-band receivers just detect a single CO line.

282 Detection of HCN and [CI] line emission in APM08279+5255 at z=3.91

Jeff Wagg (NRAO),
David J. Wilner (CfA), Roberto Neri (Iram), Dennis Downes (Iram), Tommy Wiklind (STScI)

We detect strong HCN J=5-4 emission in the ultraluminous, lensed quasar APM08279+5255 at z=3.91 using the PdBI. We also present a detection of the [CI] J=1-0 line. The linewidths and central velocities of both molecular line species are consistent with that of the high-J CO line transitions, implying that all of the emission originates within the same sub-kpc region.

283 MAMBO sources in the COSMOS field: Studying extreme high-z starburst galaxies.

Manuel Aravena, AIfA-MPIfR,
F. Bertoldi, AIfA-MPIfR, C. Carilli, NRAO, E. Schinnerer, MPA, H. Voss, MPIfR, V. Smolcic, MPA, N. Scoville, CalTech, A. Blain, CalTech, K. M. Menten, MPIfR, D. Lutz, MPE, M. Brusa, MPE, Y. Taniguchi, U Tokio

Sub-mm galaxies contribute a significant fraction of the Cosmic Star Formation History, being an important probe for understanding galaxy evolution. Using the deep optical, FIR, radio and X-ray data provided within the COSMOS project we study the 1.2 mm sources detected by the Max-Planck Millimeter Bolometer Array (MAMBO) at the IRAM 30m telescope in the central 20' x 20' of the COSMOS field.

284 The predicted H_2 density at high redshift for spiral and irregular galaxies

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Angeles I. Díaz, UAM, Madrid, Eduardo Hardy, NRAO, Chile

We have computed a wide grid of chemical evolution models for a large set of spiral and irregular theoretical galaxies of different total mass (Mollá & Díaz 2005). In our models, the gas phase has two components, the diffuse and the molecular (H_2). It is, therefore, possible to follow the time (or redshift) evolution of the expected density of the H_2 phase. We will show the predictions of H_2 gas density at hight redshift, which might be detected with ALMA, in this type of galaxies.

285 **Ammonia absorption lines towards B0218+357 and PKS 1830-211**

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Using the Effelsberg 100-m telescope, absorption in the (J,K) = (1,1) to (3,3) inversion lines of ammonia (NH_3) is detected at a redshift of z = 0.68466 toward the gravitational lens B0218+357. With the Green Bank telescope, absorption in the (J,K) = (1,1) to (10,10) inversion lines is detected at $z = 0.88582$ toward Pks 1830-211. We use multiple lines of NH_3 and HC_3N to estimate kinetic temperatures and densities and find $T_{kin}/n(H_2) \sim 55K/5 \times 10^3$ cm^{-3} and $80K/1 \times 10^3$ cm^{-3} for B0218+357 and PKS1830-211, respectively. For B0218+357, sevaeral ortho- and para-H_2CO lines observed at cm- and mm-wavelengths with the VLA, the PdBI and Effelsberg reveal a O/P ratio of 3.1. This implies that the formaldehyde was formed in a warm environment. A Tkin/n combination like that found in B0218+357 has not been seen anywhere in the Galaxy while only the envelope of the star-forming region Sgr B2 near our Galactic center shows properties matching those observed toward PKS1830-211.

286 **High-Resolution Imaging of Molecular Gas in High-Redshift Quasar Host Galaxies**

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Using the Very Large Array (VLA) we obtained high-resolution (up to 0.15′) CO $J = 1-0$ and $J = 2-1$ observations of the $z \gtrsim 4$ QSOs BRI,0952-0115, BRI,1335-0417, PSS,2322+1944, and APM,08279+5255. Only the VLA is currently able to provide a sufficient resolution to resolve molecular structures on scales of $\sim$1 kpc in distant galaxies. These observations permit a study of the spatial structure and dynamics of the molecular gas and thereby provide unique constrains on the molecular gas content and on the conditions for star formation in the early universe. The velocity structure provides dynamical mass estimates for the systems and sheds light on the role of mergers for AGN and starburst activity. These observations lay the foundation for future ALMA observations, where a resolution better than 0.1″ can be obtained through observations of higher-level CO transitions.

287 **First Light Spectra with ZEUS**

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T. Nikola, Cornell University, G.J. Stacey, Cornell University, T. Oberst, Cornell University, S. Parshley, Cornell University, D.J. Benford, NASA GSFC, S.H. Moseley, NASA GSFC, J.G. Staguhn, NASA GSFC

We present the first light spectra obtained with ZEUS, the redshift (Z) and Early Universe Spectrometer. ZEUS is a long slit echelle grating spectrometer we have constructed for use in the submillimeter windows (350 μm, 450 μm, 610 μm) on large submillimeter telescopes such as the Caltech Submillimeter Observatory (CSO). It has a resolving power R $\sim$ 1000, optimized for detecting broad, faint lines from extragalactic sources. We currently use a 1×32 array of thermistor sensed bolometers, but in the near future will upgrade to a larger array (as large as 4×64) of bolometers equipped with superconducting transition edge sensors linked into a SQUID multiplexed readout. Our primary science objective is to probe star formation in the early Universe using highly redshifted far-IR fine structure line emission - especially that of the 158 μm [C II] line. Detecting this line in high redshift galaxies will be one of the key science goals for ALMA. With our demonstrated sensitivity at the CSO, ZEUS can easily detect the [C II] line in z $\sim$ 1 to 2 HyLIRGs in 4 hours integration time. We have time at the CSO in December 2006 to pursue this science. During a May 2006 observing run we detected the ^{12}CO 6$\rightarrow$5 line from the starburst nucleus of NGC 253 and the ultraluminous galaxy Arp 220, and made first detections of mid-J ^{13}CO lines in NGC 253 and in Galactic sources, despite very poor weather (line of sight telluric transmission $\sim$ 1 %). The scientific implications of these data will be discussed.

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