SPECTRAL SURVEYS of STAR FORMING REGIONS with HIFI

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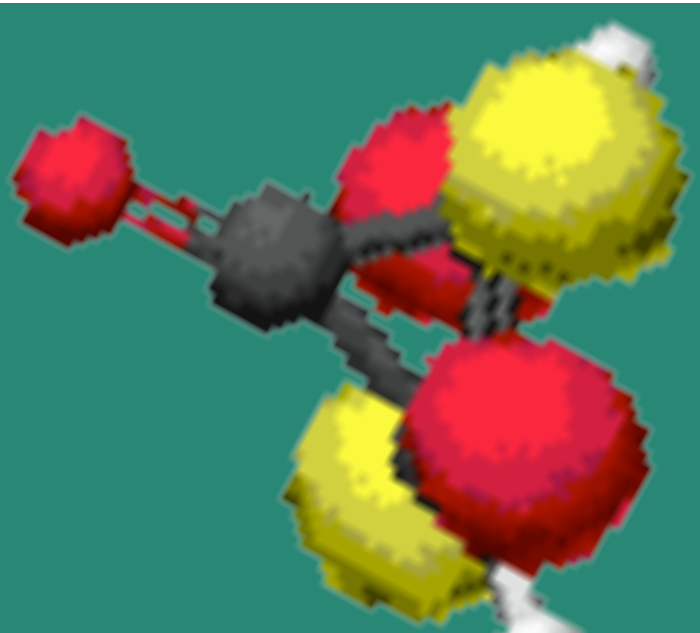
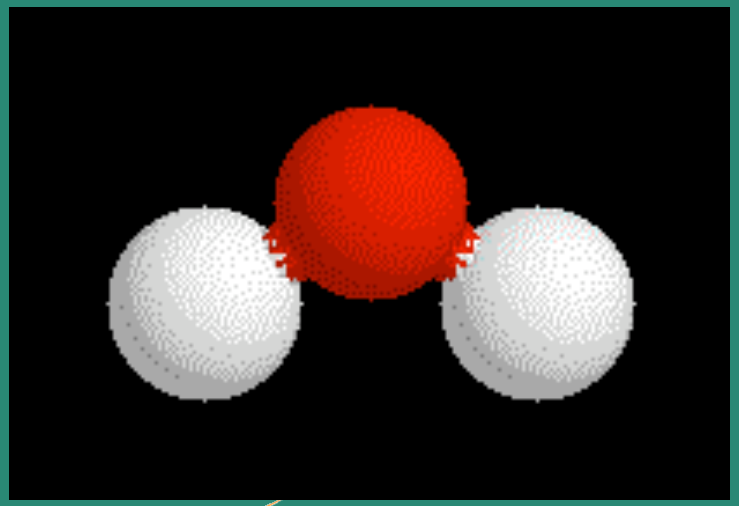


HIFI = MOLECULES



3 REASONS TO STUDY MOLECULES IN STAR FORMING REGIONS:

1. THE MOLECULAR COMPLEXITY

- *How complex are complex molecules in SFRs?*
- *When and how are they formed?*
- *What is their fate?*
- *Are they incorporated in the bricks forming the future planetary system (meteorites, comets, planets…)?* ⇨ Ex: ORIGIN of TERRESTRIAL OCEANS

3 REASONS TO STUDY MOLECULES IN STAR FORMING REGIONS:

2. THE INTERPLAY BETWEEN THE MOLECULAR COMPOSITION AND THE STAR FORMATION PROCESS

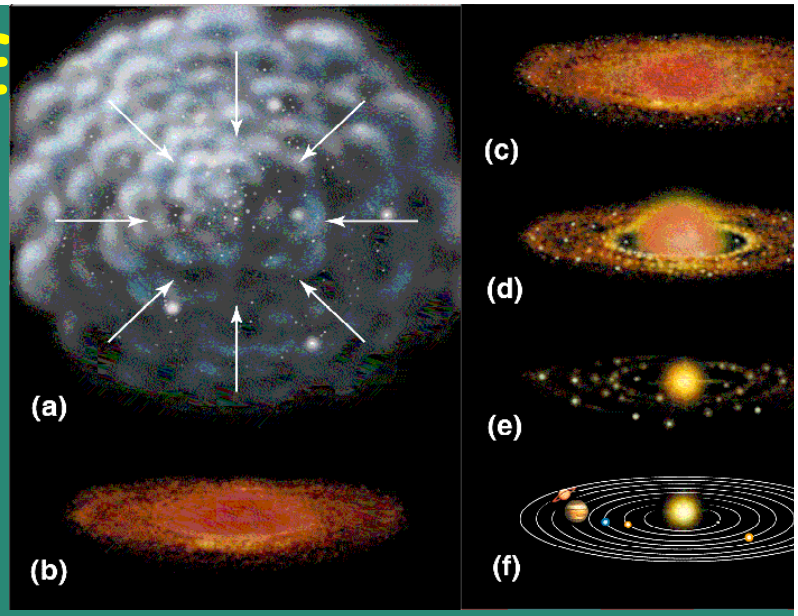
The dynamics of the collapse (and mass loss) depend on the gas temperature and coupling with magnetic fields:

- *Gas cooling => line emission*
- *Magnetic field coupling => the ions*

⇨ *both temperature and ionization degree depend on the gas chemical composition*

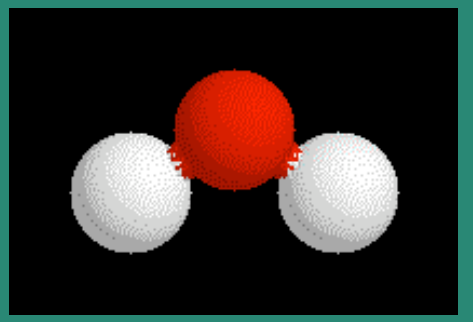
3 REASONS TO STUDY THE MOLECULAR CONTENT IN STAR FORMING REGIONS:

3. LINES ARE POWERFUL DIAGNOSTIC TOOLS



- *Different lines from the same molecule are excited in regions of different temperature and density*
- *Different molecules are formed in regions with different internal and external physical conditions*
- *Lines are the only way to study the dynamics!*

SEVERAL KEY MOLECULAR TRANSITIONS FALL IN THE HIFI RANGE



MOLECULES IN THE HIFI RANGE :

1. Major gas coolants: H_2O, CO, OH, C^+…
2. Major grain mantles components: H_2O, H_2CO, CH_3OH, NH_3…
3. Hot gas chemistry tracers: H_2O, SO_2, NH….
4. Ionization field tracers: C^+, CO^+, H_3O^+, OH, CH^+, HI…
5. Hydrides: LiH, FeH, SH, SiH….
6. Molecular deuteration: HDO, CH_2D^+, OD…
7. Molecular shocks tracers: H_2O, CO, OH….

TRANSITIONS IN THE HIFI RANGE :

1. Ground state transitions of several light molecules
2. High energy transitions of several heavy molecules

HSO HIFI KPs of SRF:

- HIFI (unbiased) SPECTRAL SURVEYS:

  A PRECIOUS AND (ALMOST) UNAVOIDABLE TOOL TO STUDY STAR FORMATION
- WATER LINE SURVEYS:

  WATER, A KEY MOLECULE ONLY DETECTABLE WITH SPACE-BORN TELESCOPES
- LINE SURVEYS OF Orion & SgrB2

1. HIFI WATER LINE SURVEY in STAR FORMING REGIONS KP

http://www.strw.leidenuniv.nl/~kempen/HIFI/

WATER IS ONE OF THE MOST ABUNDANT AND IMPORTANT MOLECULES IN STAR-FORMING REGIONS.

PI: E.van Dishoeck
Team composed by ~50 people
HIFI GT ~400hrs

GOAL: TO TRACK THE WATER ABUNDANCE, COOLING/HEATING IN SFRs, AND TO USE WATER LINES AS DIAGNOSTIC TO PROBE WARM AND DENSE REGIONS.

HIFI WATER LINE SURVEY in STAR FORMING REGIONS KP

SOURCE TARGETS:	No
Pre-stellar cores	8
Low mass	34
Intermediate mass	8
High mass	24
Disks	17
Outflows	31
YSO: Radiation	17

LINE TARGETS:

~10 lines/source of H_2O + 1 line $H_2{}^{18}O$

~3 lines/source CO, ^{13}CO

~1 lines/source of OH and H_3O^+

few lines from other molecules in specific objects:

C^+, OH^+, CH, CH^+, SH^+, NH^+

2. HIFI SPECTRAL SURVEYS OF STAR FORMING REGIONS KP : HS_3FR KP

HIFI Spectral Surveys of Star Formation Regions

TEAM MEMBERS :

A.Bacmann, A.Baudry , E.Bergin, G.Blake, S.Cabrit, P.Caselli, A.Castets, E.Caux, C.Ceccarelli, J.Cernicharo, C.Codella, C.Comito, C.Dominik, E.Falgarone, A.Fuente, M.Gerin, F.Helmich, P.Hennebelle, T.Henning, E.Herbst, T.Jacq, A.Klotz, W.Langer, B.Lefloch, D.Lis, S.Maret, F. McGroarty, G.Melnick, B.Nisini, L.Pagani, B.Parise, J.Pearson, T.Phillips, M.Salez, P.Saraceno, P.Schilke, K.Schuster, M.Tafalla, S.Thorwith, F.van der Tak, C.Vastel, S.Viti, V.Wakelam, M.Walmsley, A.Walters , F.Wyrowski, H.Yorke

PI: C.Ceccarelli

HIFI Spectral Surveys of Star Formation Regions

ULTIMATE GOAL:

A COHERENT STUDY OF THE LINE SPECTRA IN THE HIFI FREQUENCY RANGE (500-2000GHz) OF SFRs AS FUNCTION OF MASS AND EVOLUTION

IMMEDIATE GOALS :

i) TO GUIDE THE SUCCESSIVE OBSERVATIONS WITH HSO-HIFI

ii) TO PROVIDE A LEGACY DATABASE FOR THE USE OF THE GENERAL ASTRONOMICAL COMMUNITY

ALLOCATION OF HIFI TIME :

COUNTRY	HOURS
FRANCE	100
HOLLAND	70
USA	50
GERMANY	26
ITALY	20
SPAIN (+MS)	10
TOTAL	276

THE KEY TO SUCCESS:
SOURCE SELECTION

i.e. REPRESENTATIVES OF SOURCE CLASSES

- LOW MASS STAR FORMING REGIONS :

  PRE-STELLAR CORE, CLASS 0 SOURCE, OUTFLOW-SHOCK SPOT

- INTERMEDIATE MASS STAR FORMING REGIONS :

  EMBEDDED PROTOSTELLAR SOURCE

- HIGH MASS STAR FORMING REGIONS :

  HIGH MASS PROTOSTELLAR OBJECT, 2 HOT CORE SOURCES WITH LOW AND HIGH BOL LUMINOSITY

HIFI Spectral Surveys of Star Formation Regions

SOURCE LIST AND ALLOCATED GT TIME

TYPE	hr	GT Time (hr)	PI + Country Resp.
Low mass Pre-Stellar Core: L1544/16293E	25	15Fr + 10It	Bacmann, Caselli
Low mass Class 0 source: IRAS16293-2422	55	50Fr+5MS	Caux, Cernicharo
Intermediate mass Class 0 : OMC2- FIR4	50	30NL + 15Fr + 5Sp	Dominik, Ceccarelli, Fuente
Outflow-shock spot: 1557	30	20Fr + 10It	Pagani, Codella,
High Mass Protostellar Object: AGL2591	40	40NL	Helmich
High Mass Hot Core: $10^4 L_o$: NGC6334I	38	25 USA + 13Ge	Lis, Wyrowski
High Mass Hot Core: $10^6 L_o$: W51e	38	13Ge + 25USA	Comito, Lis

ON-GOING PREPARATORY WORK

a) Observations with ground-based telescopes: IRAM, JCMT, APEX, CSO

b) Modeling of the selected sources: radiative transfer and chemical models

PREPARATORY WORK: a) Observations- example 1
IRAS16293-2422 UNBIASED SPECTRAL SURVEY

INTERNATIONAL CONSORTIUM:

PI: E. Caux (CESR-Toulouse)

Co-Investigators: A.Castets, C.Ceccarelli, F.Helmich, P.Schilke, X.Tielens, E.van Dishoeck, A.Bacmann, S.Cazaux, C.Comito, C.Kahane, B.Parise, V.Wakelam, A.Walters

Institutes: CESR-Toulouse, LAOG-Grenoble, L3AB-Bordeaux, SRON-Groningen, MPI-Bonn, Leiden Obs.

STARTED IN 2003, COMPLETED IN 2006:

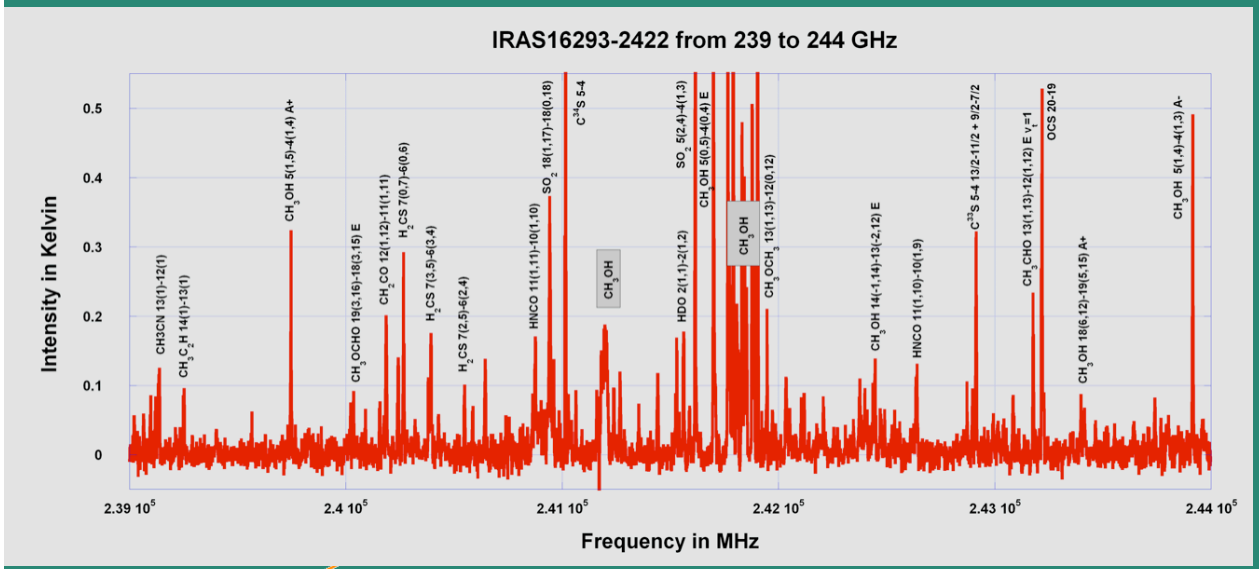
IRAM: 80-115, 129-165, 197-265; 265-274 GHz
JCMT: 328-366 GHz
APEX: 450 GHz planned, 366-370 done

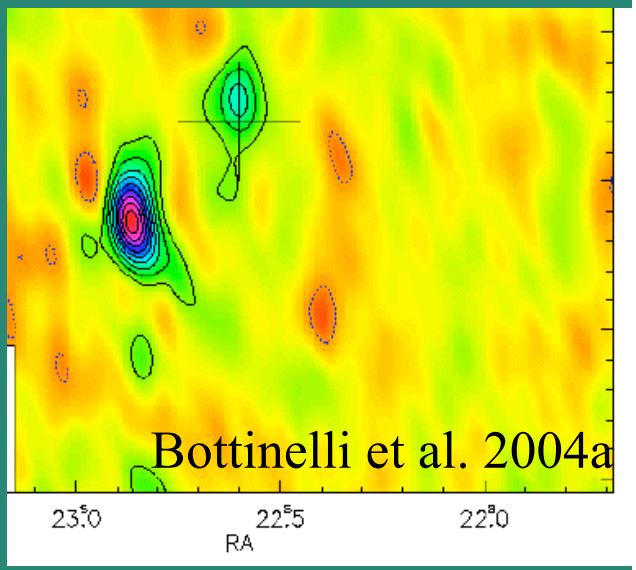
➔ DATA PUBLIC MID-2007

THE UNBIASED SPECTRAL SURVEY of IRAS16293-2422

RICH LINE SPECTRUM DOMINATED BY THE TWO COMPONENTS FORMING IRAS16293-2422:

1. THE COLD OUTER ENVELOPE, RICH OF DEUTERATED MOLECULES
2. THE WARM INNER ENVELOPE (*HOT CORINO*) ENRICHED OF COMPLEX ORGANIC MOLECULES

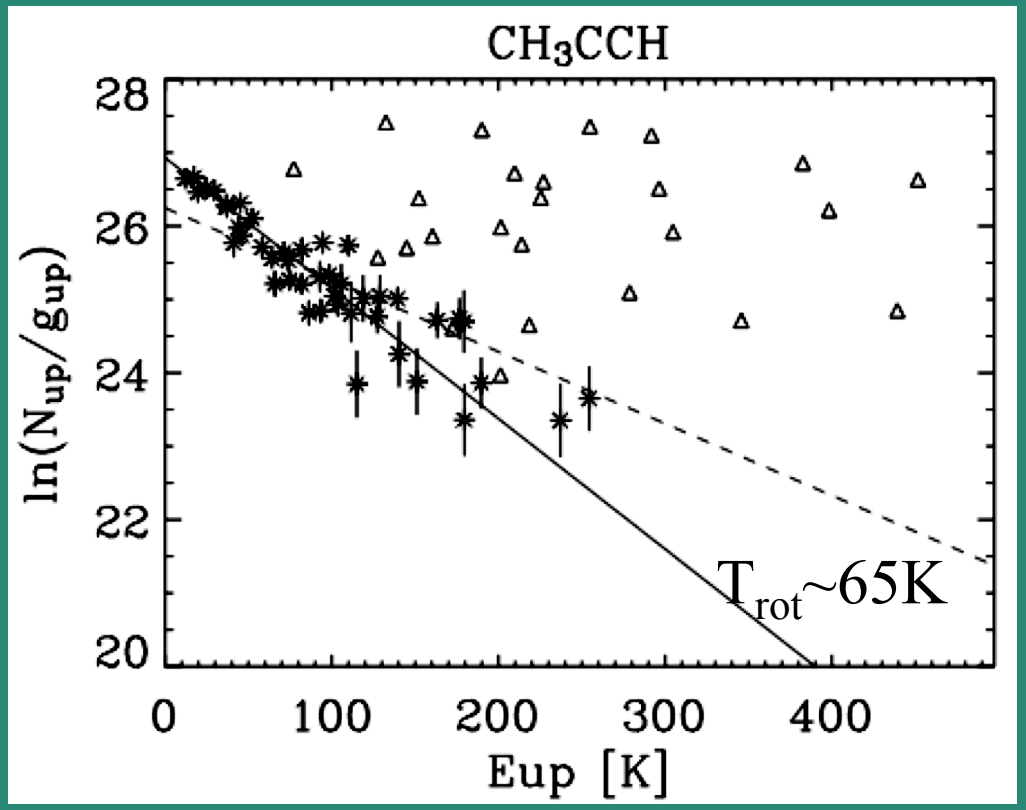


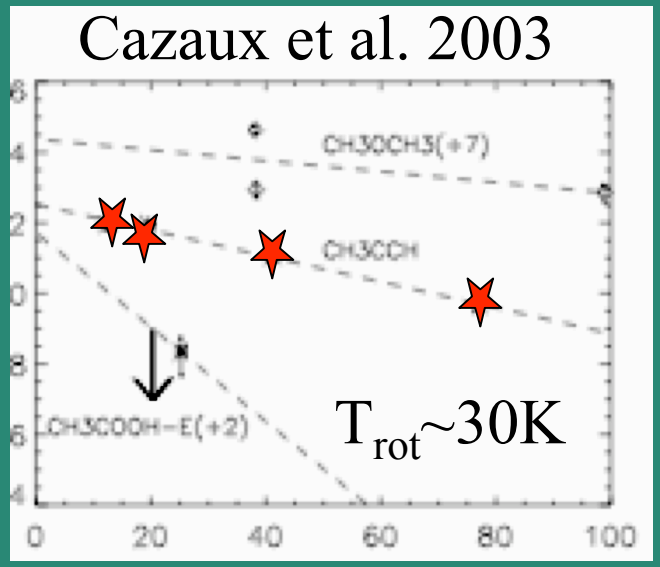


THE GROUND-TELESCOPES UNBIASED SPECTRAL SURVEY of IRAS16293-2422

SOME FIRST RESULTS:

1. PROPYNE, 4 lines previously detected (Cazaux et al. 2003) :
NEW: detected ~40 lines with E_{up} = 10 - 250K



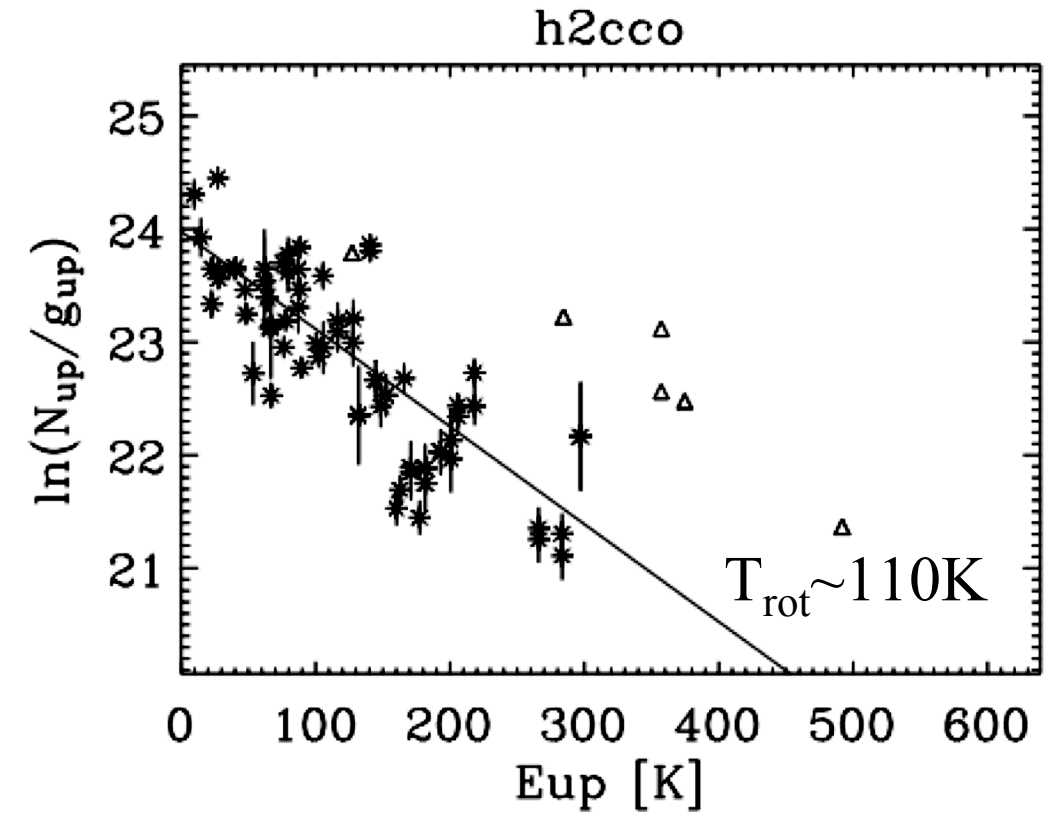


$x(CH_3CCH) \sim 3 \times 10^{-7}$
i.e. $\sim x(CH_3OH)$
$\sim 1/10 x(H_2O)$

THE GROUND-TELESCOPES UNBIASED SPECTRAL SURVEY of IRAS16293-2422

SOME FIRST RESULTS:

2. KETENE, not previously detected :
   NEW: detected ~70 lines with E_{up} = 10 - 300K



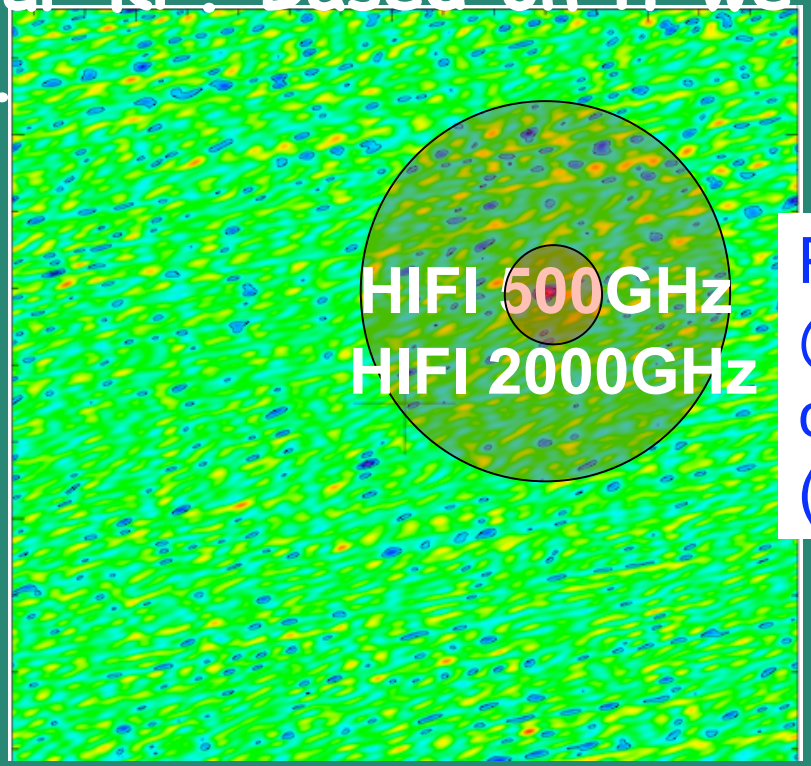
ortho/para H_2CCO ~1

x(H_2CCO)~5x10^{-8}
i.e. ~1/7x(CH_3OH)

PREPARATORY WORK: a) Observations- example 2 INTERFEROMETRIC MAPS of INTERMEDIATE MASS PROTOSTARS *

Survey (JCMT, IRAM 30mt + Pdb observations) of several intermediate mass protostars to identify the best target for our KP. Based on it we finally selected OMC2-FIR4.

*International team leaded by A.Fuente

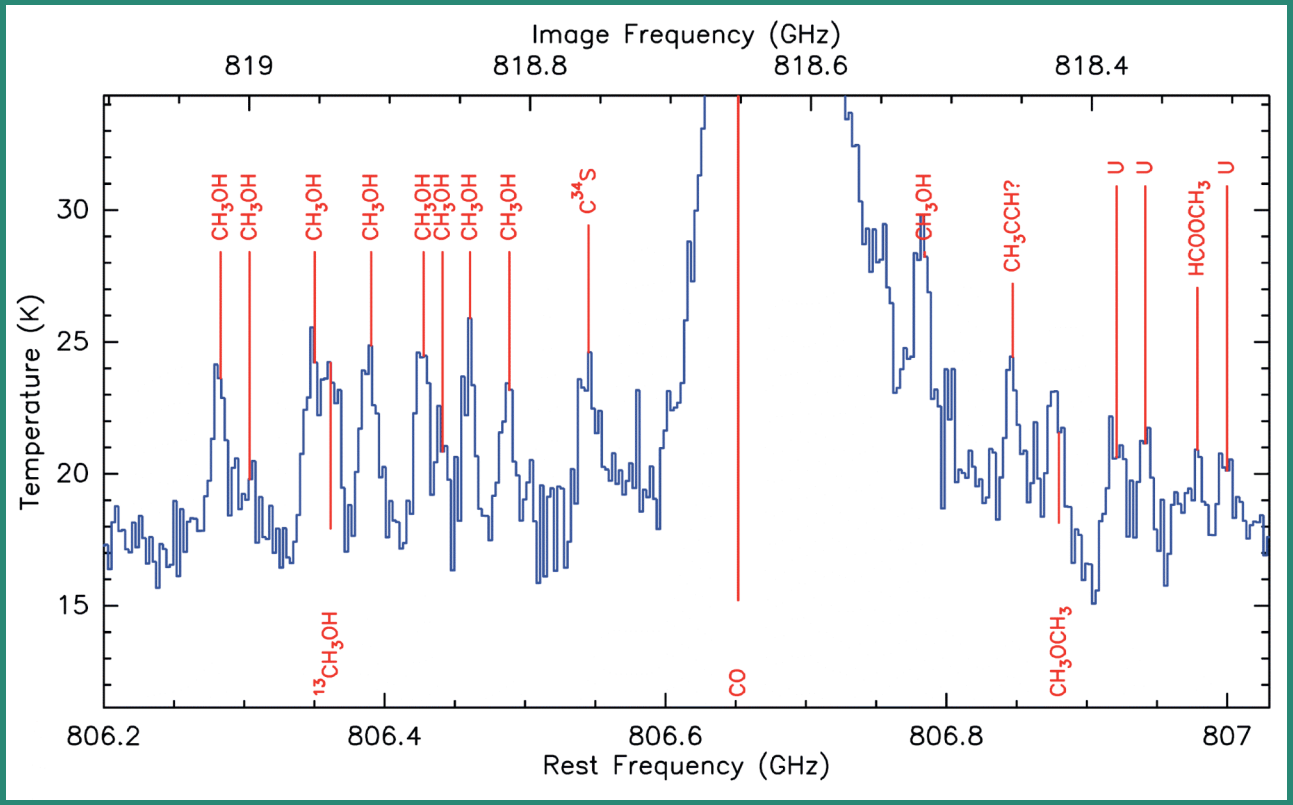


PdB map @ 1mm continuum (Mar2006)

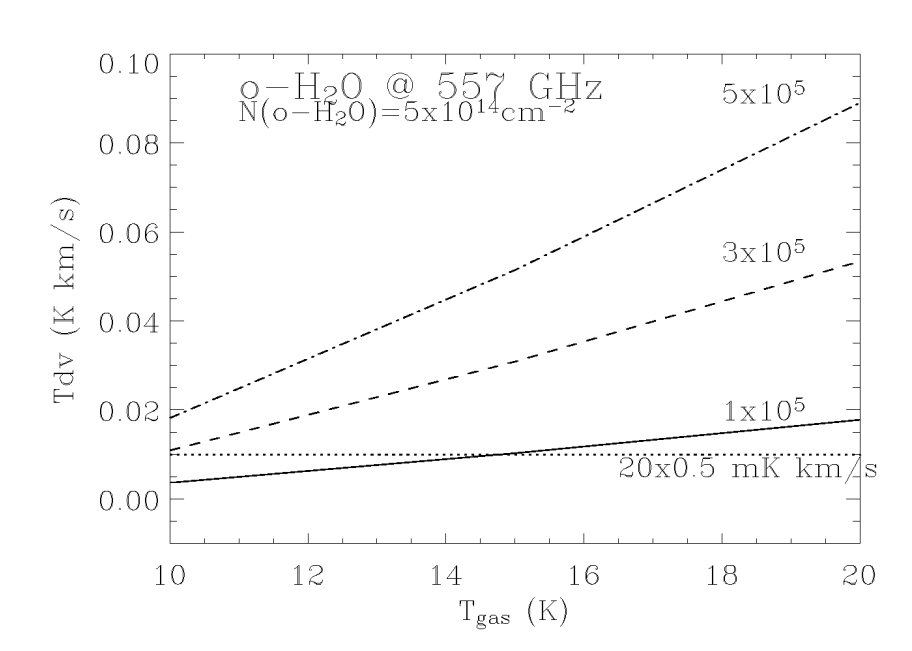
PREPARATORY WORK: a) Observations- example 3
CSO SURVEY @ 800GHz *

Survey of several massive protostars to identify the best target for our KP. Based on it we selected NGC6334I and W51e.

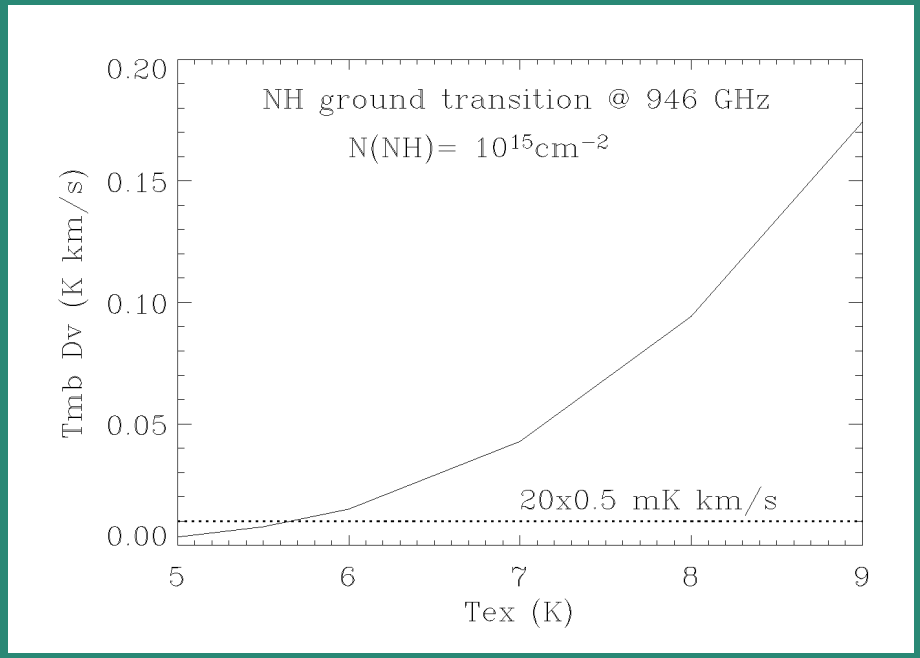
*International team leaded by D.Lis+C.Comito



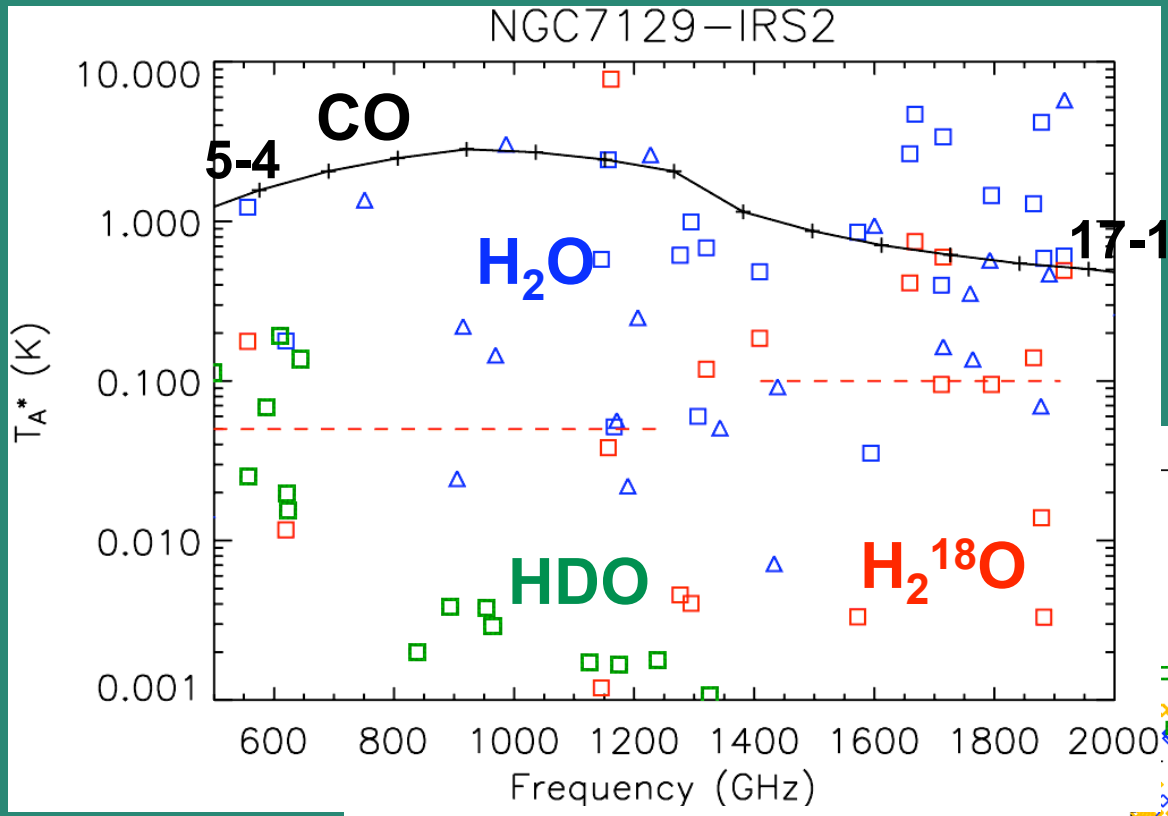
PREPARATORY WORK: a) Modeling- example 1
LINE EMISSION FROM PRESTELLAR CORES*



*International team leaded by A.Bacmann+ P.Caselli

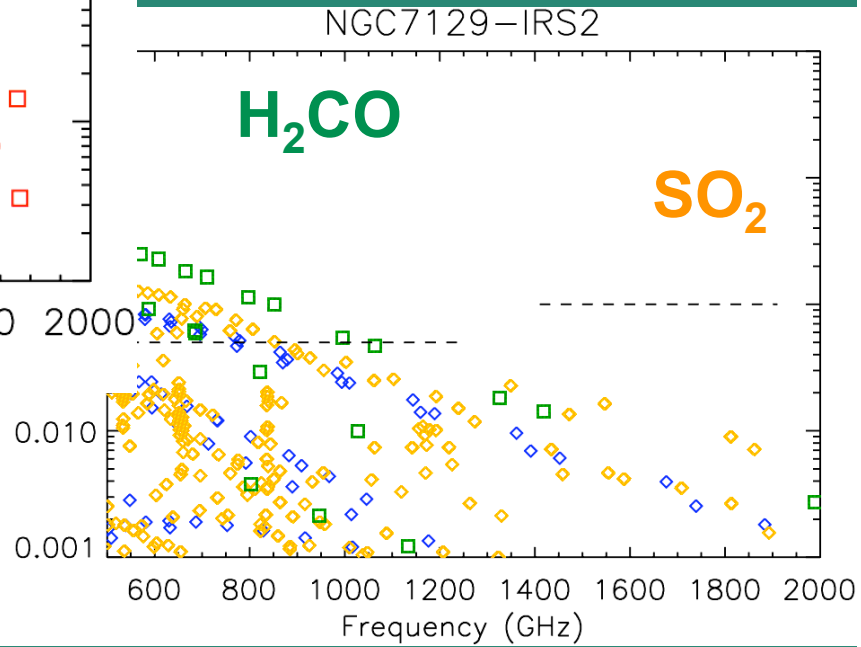


PREPARATORY WORK: a) Modeling- example 3
MAIN VOLATILES LINE MODELING OF OMC2-FIR4*



Crimier et al. (in prep.)

*International team leaded by C.Dominik+ C.Ceccarelli



4. ….GETTING TO CONCLUSIONS
(never loose your hope)

CONCLUSIONS:

WE EAGERLY WAIT FOR HIFI SPECTRAL SURVEYS OF STAR FORMING REGIONS

A PRECIOUS AND (ALMOST) UNAVOIDABLE TOOL TO STUDY STAR FORMATION