Chemical evolution in low-mass pre-stellar dense cores

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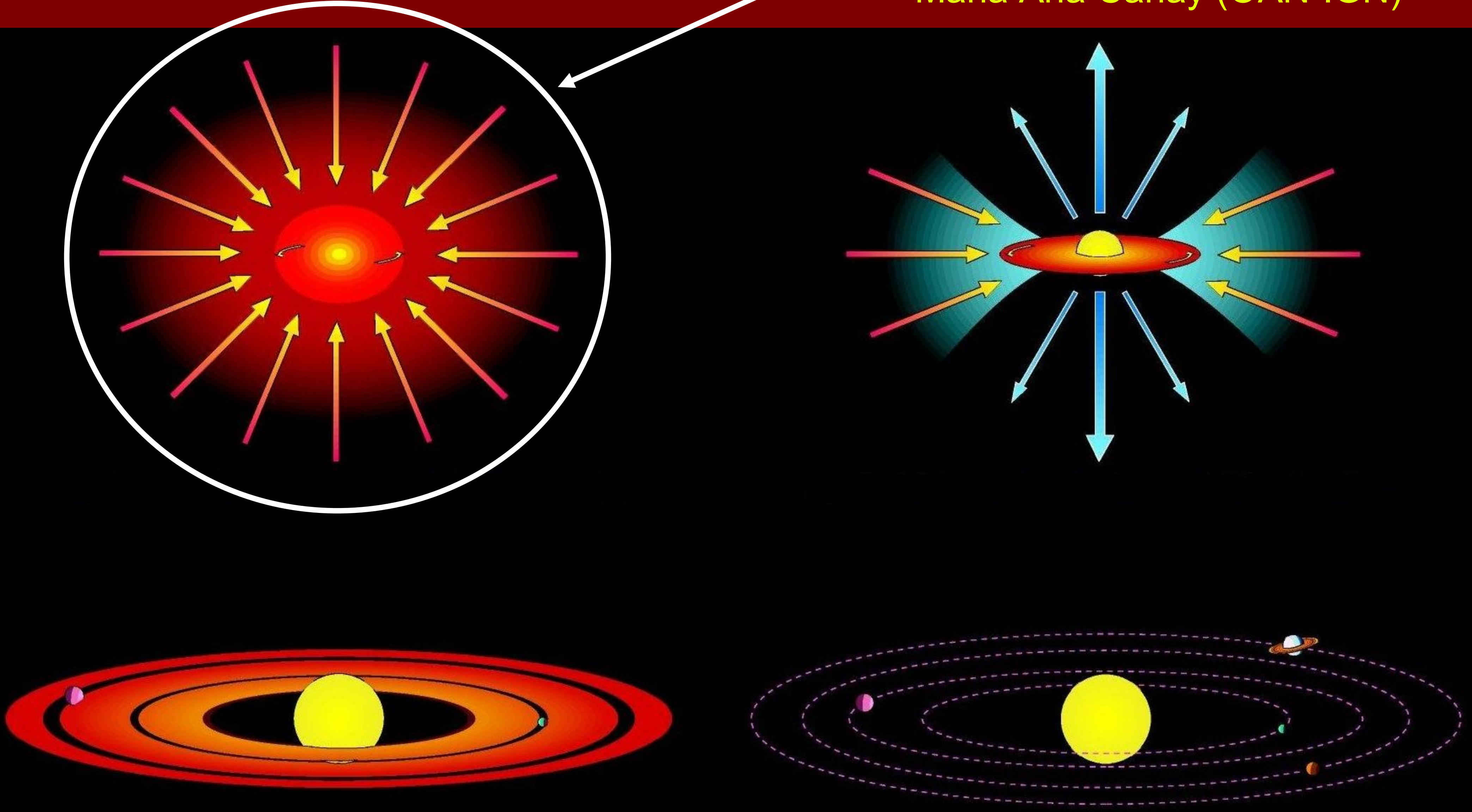


Pre-stellar dense cores

Molecular clouds are the most accesible sites where low-mass stars, like our Sun, are being born

Made of molecular material, with H_2 as the dominant constituent

Characterized by their opaque optical appearance, because of a population of dust grains

Dense cores are localized density enhancements of the cloud material

Sizes ~ 0.1 pc

Temperatures ~ 10 K

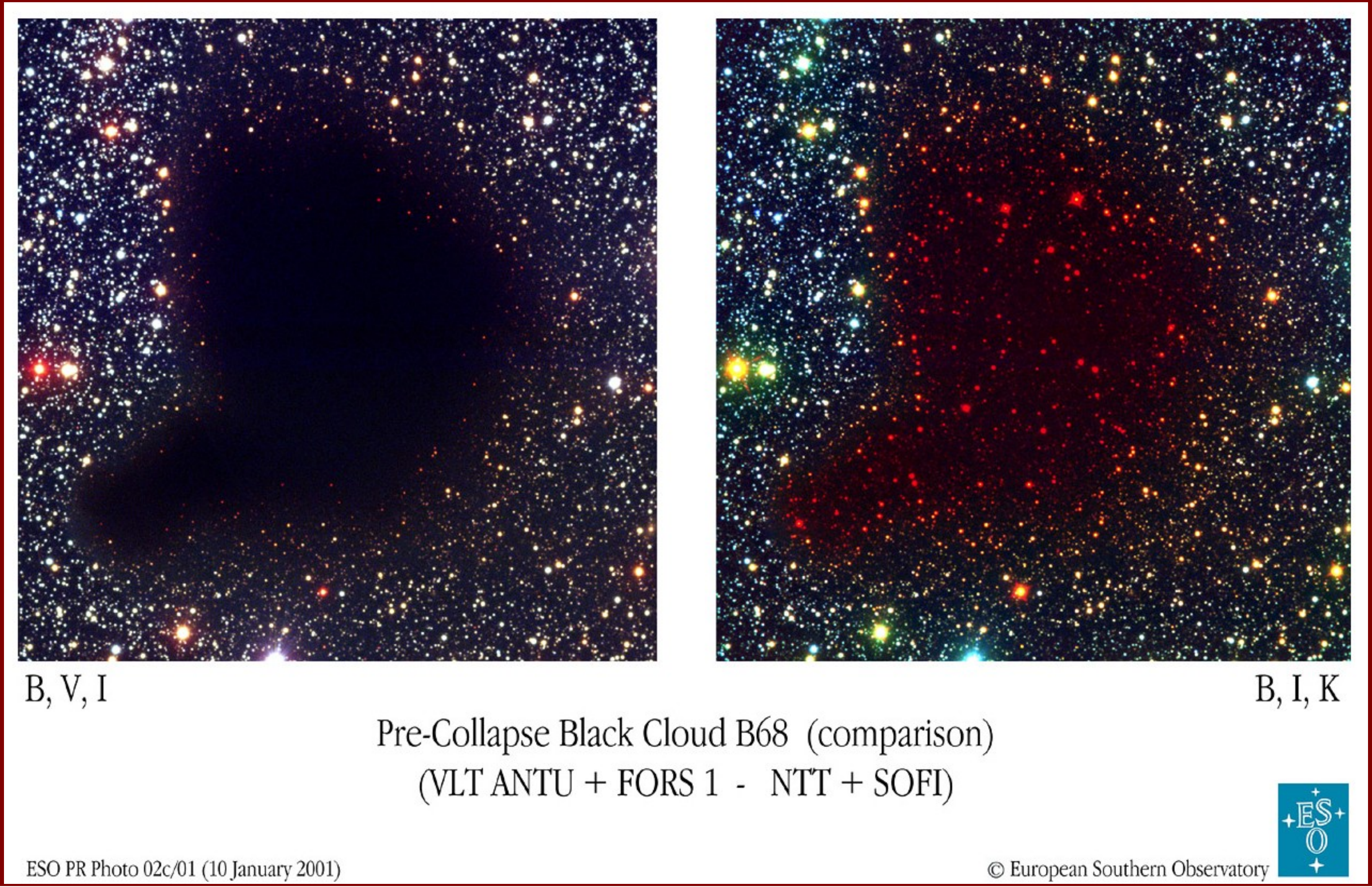
Densities ~ a few 10^4 cm^{-3}

A good example: Barnard 68

The finest examples of a type of dark cloud, known as a Bok globule
It shares many characteristics with dense cores

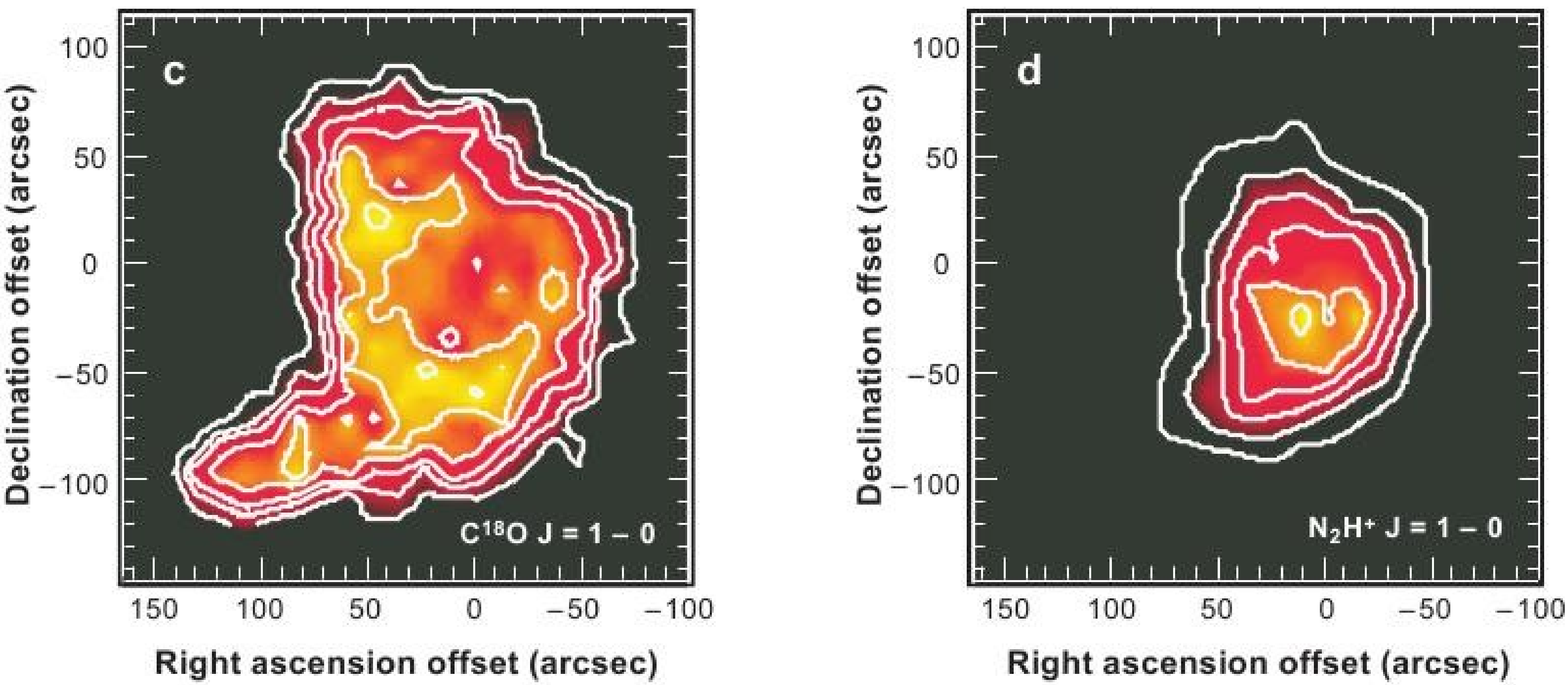
At near-infrared wavelengths, the cloud becomes transparent and the stars located behind the cloud appear very red in the image

B68 is a dynamical unit near a state of hydrostatic equilibrium, with gravity balanced by thermal pressure



Chemistry: "Selective" freeze-out

Chemical differences seen between carbon and nitrogen molecules
Freeze-out: Loss of gaseous molecules to the solid phase
Carbon-bearing molecules stick onto the dust grains and disappear from the gas phase
Nitrogen-bearing molecules survive in the central region of the cores ⟶ Best tracers to study the conditions of the dense cores interiors

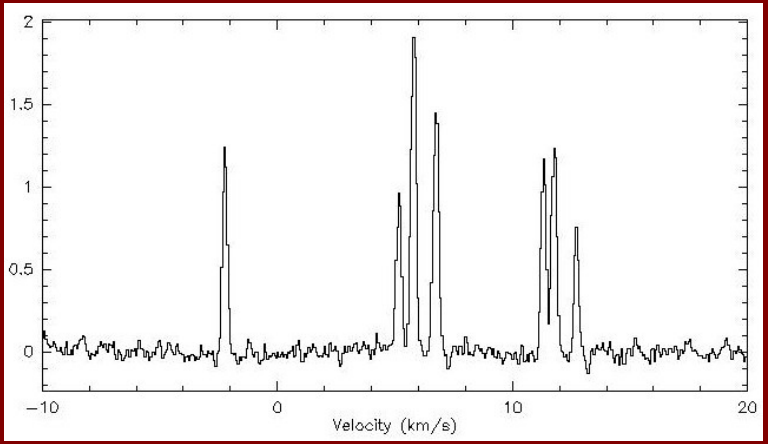


Bergin & Tafalla (2007) ARAA

This project

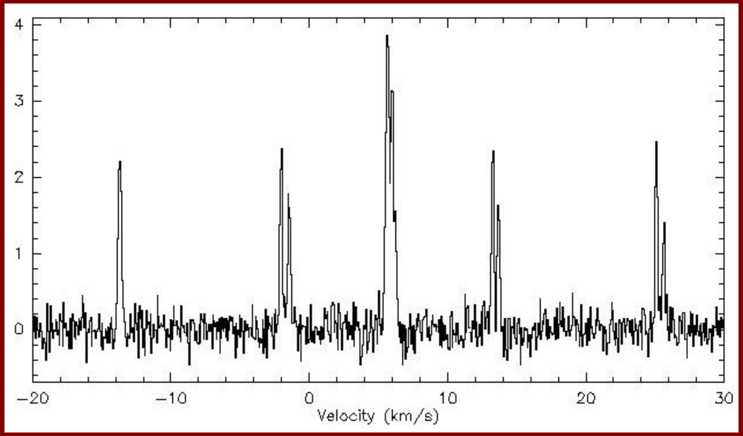
- Goal: Can we find cores at different evolutionary stages?
- Method:
  - Select sample of 13 dense cores
  - Observe cores in NH_3, N_2H^+, dust continuum
  - Convert observed intensities into NH_3 and N_2H^+ abundances
  - Compare abundances in the sample

Observations

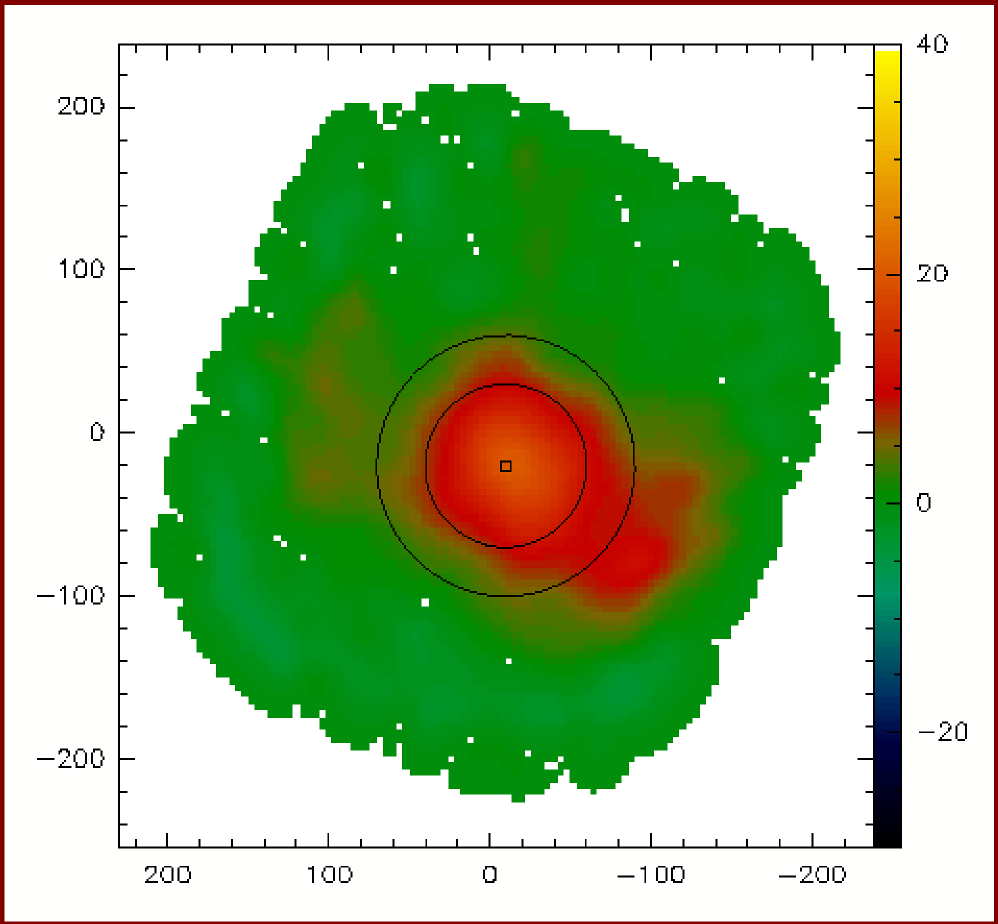


N_2H^+

NH_3



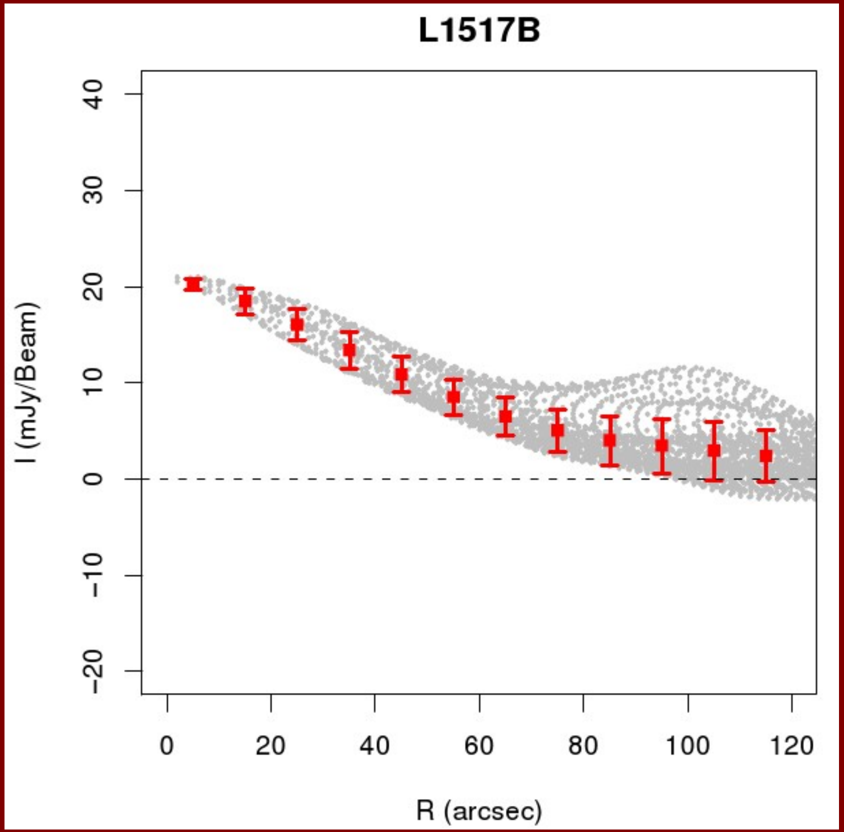
L1517B: 1.2 mm continuum



IRAM, L1517B, smoothed image with spatial resolution of 26 arcsec

The 1.2 mm continuum in starless cores is a faithful tracer of the gas component, so the density structure of prestellar cores is estimated through the analysis of dust continuum emission

$$F_{1.2mm} \longrightarrow N(H_2)$$



L1517B: N_2H^+ and NH_3

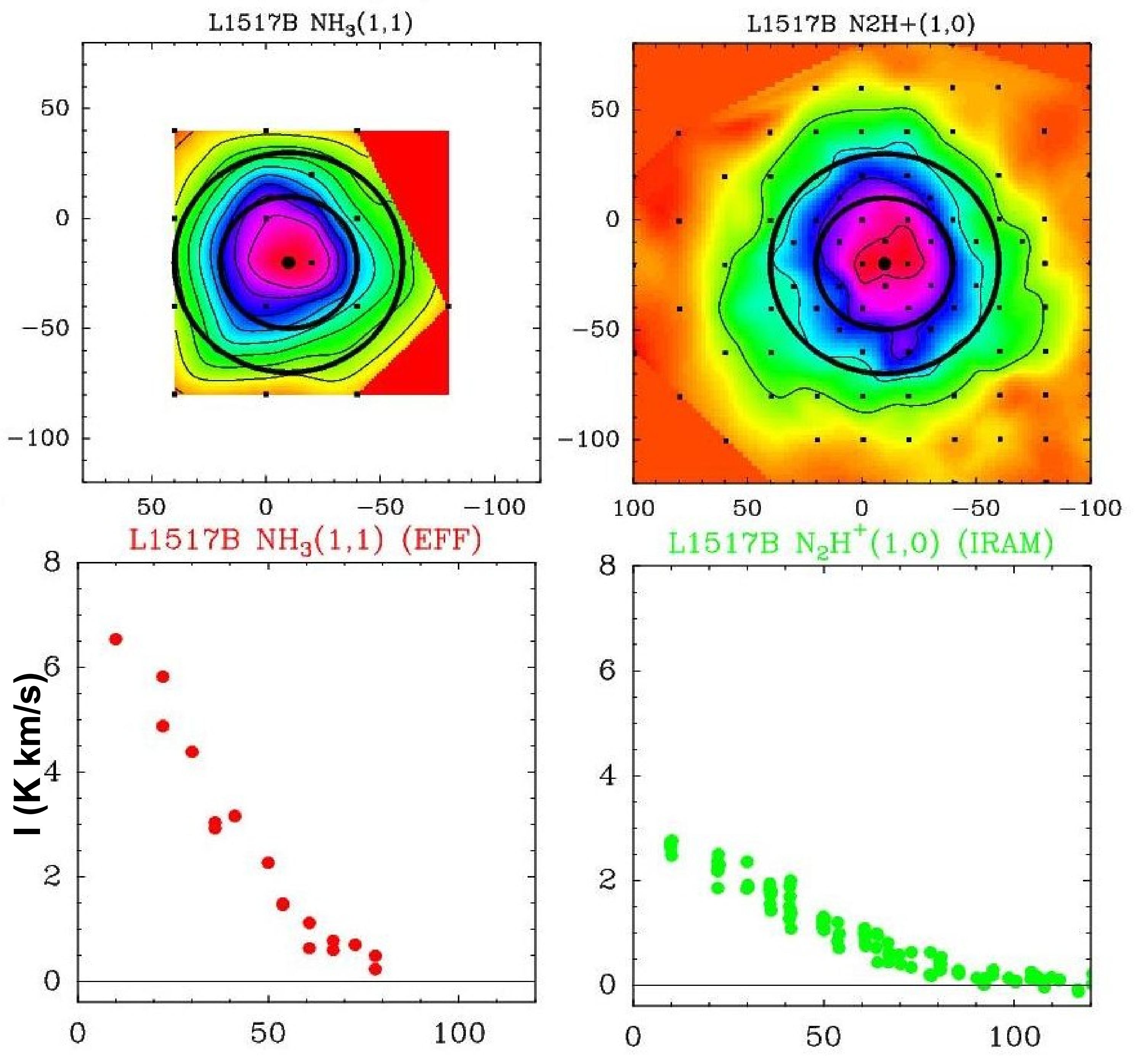
The line maps represent integrated intensities, measured in NH_3 and N_2H^+ lines

Together with continuum map, they have approximately the same peak position

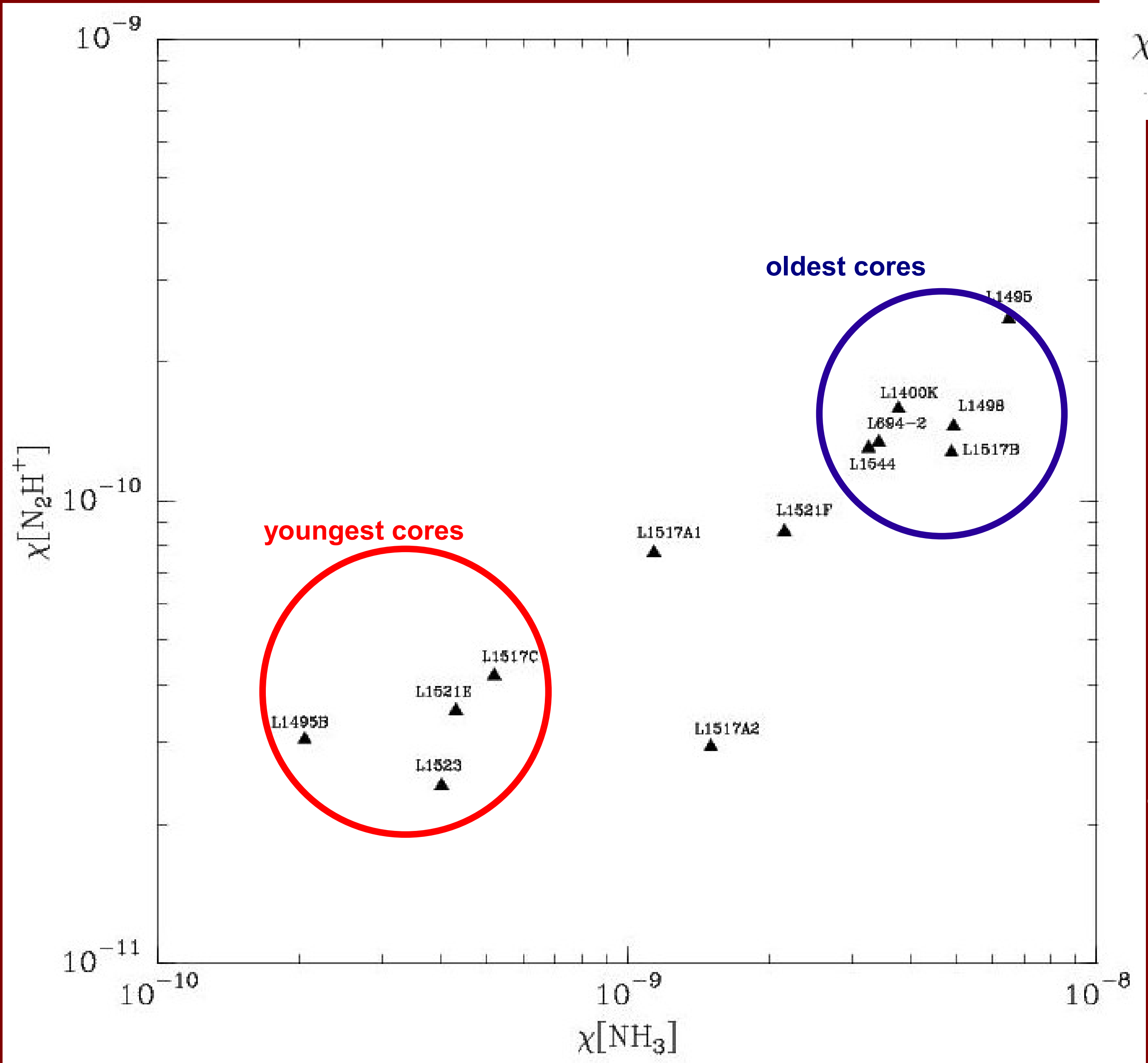
Near spherical morphologies

$I(NH_3) \longrightarrow N(NH_3)$

$I(N_2H^+) \longrightarrow N(N_2H^+)$



NH_3 and N_2H^+ abundances



$$\chi(NH_3)\alpha\frac{N(NH_3)}{N(H_2)}$$

$$\chi(N_2H^+)\alpha\frac{N(N_2H^+)}{N(H_2)}$$

» Low abundance values → young cores

High abundance values → evolved cores

» Correlation between both abundances

» NH_3 abundance increase more than N_2H^+

Future work

- Use a Monte Carlo model to make a better estimates of N_2H^+ and NH_3 abundances.

- Model chemical evolution of dense cores

- Study changes in physics during core evolution