Chemical Sub-structure of High-mass Star-forming Regions

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Introduction

Although the formation of high-mass stars (M > 8M⊙) is still not well understood, these objects are often associated with energetic outflows, finally exploding as supernovae. Besides strongly modifying the physical conditions in their environment, they exhibit extremely rich astrochemical process.

Although not always observed with the same tracer, accretion disks have been suggested in numerous systems. Significant chemical diversity in these regions, can not only been seen on large scales in terms of the large number of molecular detections, but in particular is, also found on the small scale.

Deciphering the variation of chemical properties within high-mass star-forming regions in different evolutionary stages can not only indicate the existence of substructures and dynamics, like outflows, disks and shocks, but more important, provide evidences for different theoretical formation models .

Status Quo

Integrated properties, single-dish line surveys (different low spatial resolution, different frequency bands)

- Submm interferometric observations in the same spectral setup at high-spatial-resolution;
- a rather uniformly selected sample of young deeply embeded sources in various stages (prominent e.g. Orion-KL, W3OH/H2O or Cepheus A), observed over a few years

Past → Present

☹ *How our emerging picture of the physical evolution is related to the observed chemical diversity and evolution (not clear).*

☹ *Challenges from observational and theoretical difficulties (e.g., Searching for disk signature, Cesaroni et al. 2007).*

Method

Synthesize

Submillimeter Array high spatial resolution chemical survey data of massive molecular cores, which contains high-mass protostars in different evolutionary stages

Estimate

column densities and abundance for all sources and detected species (distinguish the spectral characteristics as a function of chemical evolution from other factors, such as, extinction and optical depth effects), and comparing the spatially resolved molecular emission.

Model

Model the chemical evolution of massive warm molecular cores, directly compare with the data.

Further

statistical search, identify suitable tracers for each type of sources, chemically as a function of evolutionary state, to probe the structure of, e.g., massive disk.

Techique

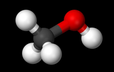
SMA: Submillimeter Array

PdBI: Plateau de Bure Interferometer

ALMA: Atacama Large illimeter/submillimeter Array

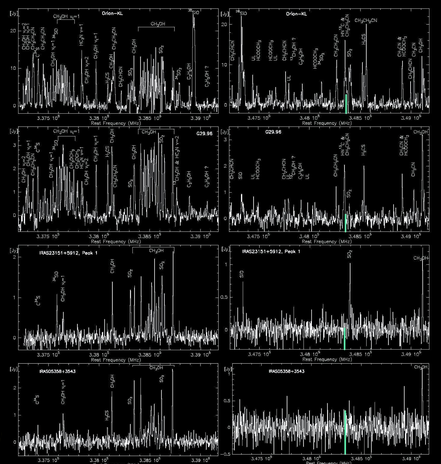
Expectation

Previous statistical database is still too poor to set tighter constraints, but those observations give the direction how one can use the presence and morphology of various molecular lines to identify and study different (chemical) evolutionary sequences. With the comparison from larger database, more similar ties or differentces in physical and chemical processes will be revealed important to produce the complex chemical signatures



(e.g., the detection of rich vibrationally torsionally excited CH_3OH line as the indicator of the temperature of different evolutionary stages; $C^{34}S$ as evidence of temperature-selective gas-desorption processes and successive gas chemistry networks; nitrogen bearing molecular lines perhaps relating to the fact that NH_3 is bonded within the water ice mantle,etc.) ;

From an observational and technical point of view, although the presented data are state of the art multiwavelength and high angular resolution observations, the quantitative interpretation is still hampered by the spatial filtering of the interferometer. Therefore, to complement such data with the missing short spacing information is our goal of further study.



(Beuther et al. 2009 Fig.2: SMA spectra toward the four target regions (each row corresponds to one source). All data-cubes were smoothed to the same spatial resolution of ~5700AU. The green line marks the position of an interesting nitrogen-bearing molecular line.)

References

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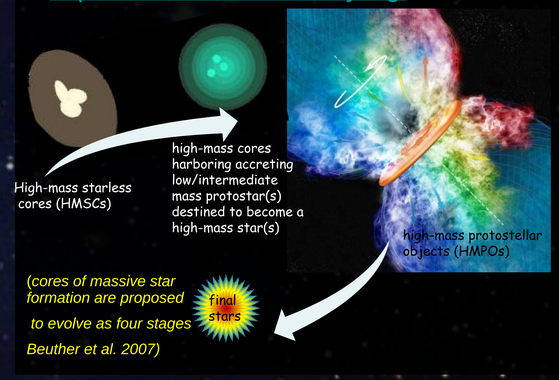

About Me

As an IMPRS student, I began my PhD project with Priv.-Doz. Dr. Henrik Beuther in September 2011.
Here is our study plan so far.
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Nov.8th, 2011

We acknowledge the financial support by LASSIE FP7 Marie Curie Initial Training Network (ITN)