Toward a Chemical Evolutionary Sequence in High-Mass Star Formation

Thomas Gerner, Henrik Beuther, Dmitry Semenov, Hendrik Linz, Tatiana Vasyunina, and Thomas Henning

Abstract Understanding the chemical evolution of young (high-mass) star-forming regions is a central topic in star formation research. The chemistry plays two main roles here: to study the evolution from simple to complex molecules, and to investigate the underlying physical processes. With these aims in mind, we observed a diverse sample of 60 high-mass star-forming regions in different evolutionary stages. In the early phase, quiescent Infrared Dark Clouds (IRDCs), consisting of cold and dense gas and dust, and emitting mainly at (sub-)millimeter wavelength, are formed. In the next phase, the so called High Mass Protostellar Objects (HMPOs) form, which host a central, likely still accreting protostar and already show emission at mid-infrared wavelengths. In the Hot Molecular Core phase (HMC) the central source heats up the surrounding environment, evaporating molecular-rich ices, which gives rise to a rich chemistry leading to complex molecules such as long carbon chains. Finally the UV-radiation from the embedded protostars ionizes the gas around and forms an Ultra Compact HII (UCHII) region. In these objects many of the previously formed complex molecules are not longer detected as they got destroyed by the ionizing radiation. For our observations, we used the IRAM 30m telescope with the total bandpass of 16 GHz and good spectral resolution ($\sim$0.3/0.7 km/s at 1/3 mm). We derived their large-scale chemical abundances, assuming LTE and optically thin emission. To set these results into context, we model the chemical evolution in such environments with a state-of-the-art chemical model. This enables us to put constraints on the chemical evolution, the age and parameters such as the temperature and the density of the molecular clouds.

T. Gerner (✉) • H. Beuther • D. Semenov • H. Linz • T. Henning
Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany
e-mail: gerner@mpia.de

T. Vasyunina
University of Virginia, Charlottesville, VA 22904, USA

D. Stamatellos et al. (eds.), *The Labyrinth of Star Formation*, Astrophysics and Space Science Proceedings 36, DOI 10.1007/978-3-319-03041-8_81,

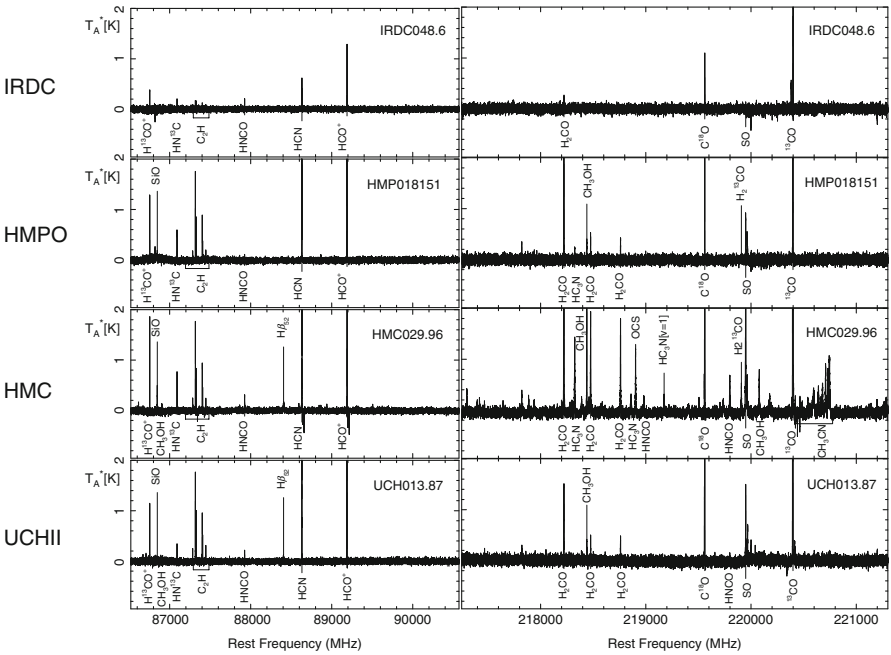

Fig. 1 From *top* to *bottom* characteristic example spectra of the four sources IRDC048.6, HMPO18151, HMC029.96 and UCH013.87 for each of the four evolutionary stages in high-mass star formation for 8 GHz of the total bandpass of 16 GHz are shown

1 Comparison Between Data and Model

As a starting point to verify the feasibility of our 1D-physical model coupled to an extended chemical model [1], we first modelled IRDC048.6. The abundances of 10 out of 13 species which were compared with the best fit model matched within their errors. Only the two complex molecules HNCO and H_2CO showed larger deviations of more than one order of magnitude, which is due to a lack of understanding their complete reaction network in particular, surface processes. In the coming future we want to apply the modelling to all our observed IRDCs and extend the model to the later stages and fit them as well (Fig. 1).

Acknowledgements T.G. is funded from Sonderforschungsbereich "The Milky Way System" (SFB 881) of the German Research Foundation (DFG) via subproject B3.

Reference

1. Semenov, D. et al. (2010), A&A, 522A, 42S