Universe: Recent Successes and Current Challenges

Variations of molecular abundances in regions of high mass star formation

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Abstract. We summarize the results of our studies of chemical differentiations in regions of high mass star formation based on molecular line and dust continuum observations. The results reveal significant differences between high-mass and low-mass cores. In particular, in the former ones N_2H^+ abundance drops in the vicinity of bright YSOs while CS is a good tracer of total mass.

Keywords. astrochemistry, stars: formation, ISM: abundances, ISM: molecules, radio lines: ISM

Understanding high mass star formation (HMSF) is still a challenge for astrophysics. And in order to investigate physical processes in these regions it is important to know their chemical features since molecular emission is the primary probe of the physical conditions in interstellar clouds. It is now well established that the central parts of dense low mass cloud cores suffer strong depletion of many molecules (in particular, CO, HCO^+ and CS) onto dust grains (e.g. Caselli *et al.* 1999, 2002, Tafalla *et al.* 2002, Bergin *et al.* 2001). On the other hand, N_2H^+ is an excellent tracer of dust continuum emission (Caselli et al. 2002), implying that this species does not deplete out. The situation is different in HMSF cores as shown below.

Our observations of a sample of HMSF cores in lines of several high density tracers (CS, N_2H^+, HCN, HNC, HCO^+, their isotopes, etc.) and in dust continuum emission at 1.2 mm reveal certain relationships between them which are different from those seen in cold low mass cores (Zinchenko *et al.* 1995, 1998, Pirogov *et al.* 2003, Pirogov *et al.*, in preparation, Zinchenko *et al.*, in preparation). Here we summarize the main results.

The most striking feature is a strong difference in many cases between N_2H^+ distribution and distributions of most other species. CS, HCN and HCO^+ usually follow well dust continuum emission while N_2H^+ does not. This is opposite to the situation in cold low-mass cores. The variations of the CS(5–4)/N_2H^+ intensity ratio reach more than an order of magnitude, as shown in Fig. 1 where we plot this ratio in dependence on the distance from the CS/dust peak for one of the sources. HNC distribution is usually intermediate between CS and N_2H^+ ones.

Estimates of the physical parameters of the cores do not show significant differences

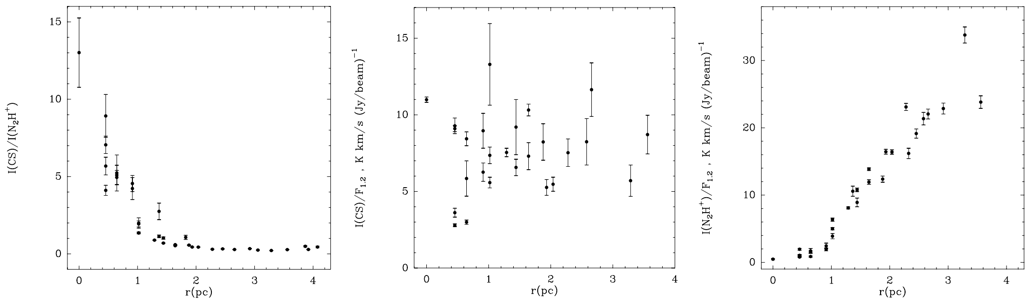

Figure 1. Intensity ratios CS(5–4)/N_2H^+(1–0) (left panel), CS(5–4)/dust (central panel) and N_2H^+(1–0)/dust (right panel) in dependence on the projected distance from the CS/dust peak for G285.26-0.05.

between the CS and N_2H^+ peaks although the CS peaks are somewhat warmer and denser on the average. Typical temperatures which we derived from the CH_3CCH data for these peaks are $\sim 30-40$ K (Malafeev *et al.* 2005). Therefore, the observed chemical differentiations cannot be explained by molecular freeze-out as in low mass cores. The absence of CO depletion is confirmed by estimates of $C^{18}O$ abundance from comparison with dust emission. In general, N_2H^+ abundance decreases in vicinities of bright IR sources.

One possible explanation for the observed chemical differentiations was proposed by Lintott *et al.* (2005). They suggested that the enhancement of CS/N_2H^+ abundance ratio found in HMSF regions may be related to the high dynamical activity in these regions which could enhance the rate of collapse of cores above the free-fall rate. Consequently, high gas densities would be achieved before freeze-out had removed the molecules responsible for N_2H^+ loss, while the high densities promote CS formation. Our data show that the line widths in most cases are somewhat larger at the CS peaks than at the N_2H^+ ones. However, other mechanisms can affect the N_2H^+ abundance near massive (proto)stars, such as an enhanced destruction rate due to a larger ionization degree. All this has to be explored.

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