

Into the Snake Pit: How Star Formation Affects Chemistry in the Serpens Molecular Cloud

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Abstract. Single-dish and interferometer observations in N_2H^+ , HCN, and HCO^+ $J=1-0$ emission from the Serpens star forming cloud show the effect of the protostellar jets on the chemistry of these dense gas tracers. N_2H^+ is a reliable tracer of overall column density, but is destroyed in shocks; HCO^+ and HCN emission is strongly increased near outflows.

Keywords. ISM: molecules, ISM: jets and outflows, Stars: formation

1. Introduction

Many young stars drive powerful jets (Bachiller 1996). These jets influence the physical structure of the star-forming cloud by sweeping up material and increasing the turbulence, and change the chemical composition of the gas through reactions in the shocked gas, evaporation of icy grain mantles, and destruction of the grains. An important question therefore is the extent to which the emission lines of commonly used dense-gas tracers such as HCO^+ , HCN, and N_2H^+ are affected by this outflow activity. This has relevance for detailed studies of star-forming regions in our own Galaxy, and for spatially unresolved studies of star-forming complexes in other galaxies.

The Serpens molecular cloud is well suited to investigate how the millimeter-wavelength line emission of HCO^+ , HCN, and N_2H^+ is impacted by the ongoing star formation. Serpens (~ 310 pc) harbors numerous deeply embedded protostars and starless dust condensations (Casali et al. 1993). Seen in submillimeter continuum tracing the cold dust, the molecular cloud consists of two subcondensations, northeast (NE) and southwest (SW), each of which are broken up into clumps and filaments. Many outflows emanate from the Serpens region (Davis et al. 1999).

The poster presents observations of the HCO^+ , HCN, and N_2H^+ line emission of the Serpens cloud, and studies the relation with the numerous outflows.

2. Observations

The single-dish observations, obtained at the 12-meter telescope of the Arizona Radio Observatory on Kitt Peak with a beam size $60''$, cover a $420'' \times 420''$ area encompassing the NE and SW condensations in HCO^+ , HCN, and N_2H^+ $1-0$. Interferometer observations from the millimeter array of the Berkeley-Illinois-Maryland Association (BIMA) cover a $400'' \times 260''$ area around the SE condensation in a 13 point mosaic at a resolution of $15''$. The NW condensation has been previously studied by Williams & Myers (2000).

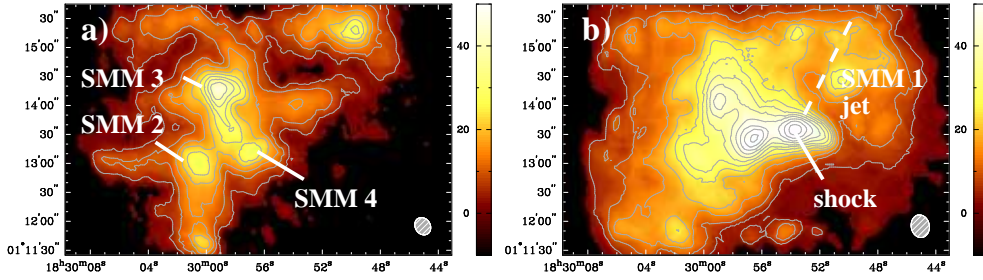


Figure 1. Combined single-dish and interferometer data of Serpens SE in (a) N_2H^+ , (b) HCN.

3. Results

Comparison with the $850\ \mu\text{m}$ emission tracing cold dust shows that the N_2H^+ reliably traces the quiescent cloud material (Fig. 1a). The HCO^+ and especially they HCN emission is clearly enhanced close to known outflows (SMM 3 and SMM 4; Fig. 1b). The location of the most intense HCN emission in the region (also strongly blueshifted) coincides with a so-far unrecognized bow shock. (Fig. 1b). This shock, visible as a clear V-shaped structure in previous CS imaging from OVRO (Testi et al. 2000), is likely caused by the (counter) jet from SMM 1 penetrating into the cloud; it lies almost exactly 180° from the known jet emanating from SMM 1 toward the northwest (Rodríguez et al. 1989).

A preliminary analysis of the abundances shows that N_2H^+ has typical dark-cloud values (few times 10^{-10}) throughout the region, while the HCO^+ and HCN abundances increase by factors of a few near the outflows. For HCO^+ , 25% of the line emission averaged over the entire mapped region originates from near outflows. For N_2H^+ this fraction is only 12%. For HCN this number is 15%, due to the presence of extended emission throughout the core as well. Further investigation is required to determine if this extended emission is due to ‘churning’ of the cloud by the many outflows.

In the bow shock region, the spatial offset between the HCN (at the tip) and the N_2H^+ emission (on the sides) clearly shows the anticorrelation of these two tracers that have very similar excitation conditions. The poster presents results of a simple chemical model where the HCN abundance increases sharply in more strongly shocked, warmer material, while the N_2H^+ abundance drops due to reactions with CO and H_2O released from the icy grain mantles.

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