Complex Hydrocarbons in High Mass Star Forming Regions

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What is Warm Carbon Chain Chemistry (WCCC)?

To account for the higher presence of Warm Carbon Chain Molecules (WCCMs) than expected in star-forming regions, Sakai et al. (2008) proposed the theory of WCCC. This theory suggests that when a protostar is in the initial phase of formation, carbon and hydrogen freeze-out onto the surfaces of dust grains and collide to form WCCMs. In particular, WCCC is thought to begin with the formation and subsequent evaporation of CH_4 off of grain mantles. The gaseous CH_4 would be abundant in this warm region that extends around the protostar and could react with ionized carbon to form more complex CCMs.

DR 21(OH)

Motivation

Although there is a theory for the chemical reactions to produce WCCMs, the physical phenomena that impact the formation mechanisms of WCCC are still unknown. What are the physical conditions in HMSF regions that cause WCCC? We have developed a framework in which to interpret future observations of HMSF regions. We verified our method using archived spectral data of well-known tracers of density and outflow in DR 21(OH) by modelling the molecule column density and comparing the density ratio maps to known features in DR 21(OH).

DR 21(OH): from previous observations

- A HMSF region active in star formation and is known to have global infall.
- High angular resolution continuum observations of its core indicate the presence of two sources, called MM 1 and MM 2, which split into smaller clumps at scales of 1 000 AU—denoted by the x's in Figure 1.
- Has a Keplerian-like disk and two low-velocity outflows: one blue-shifted in the southeast direction and one red-shifted in the northwest direction.
- Has a warm background component and a cooler foreground component, which cause self-absorption.

Physical Parameters from Spectra

We used archived James Clerk Maxwell Telescope (JCMT) data of the tracer molecules HCN, HCO^+, $H^{13}CO^+$, and SiO.

Data for each molecule was in the form of a datacube (see left side of Figure 2). After splitting each pixel into a separate FITS file, we could model the molecule column density, temperature, FWHM, and bulk flow of each spectra using a Monte Carlo Markov Chain in CASSIS (see right side of Figure 2).

Features of the region are seen by making column density ratio maps (see Figure 1).

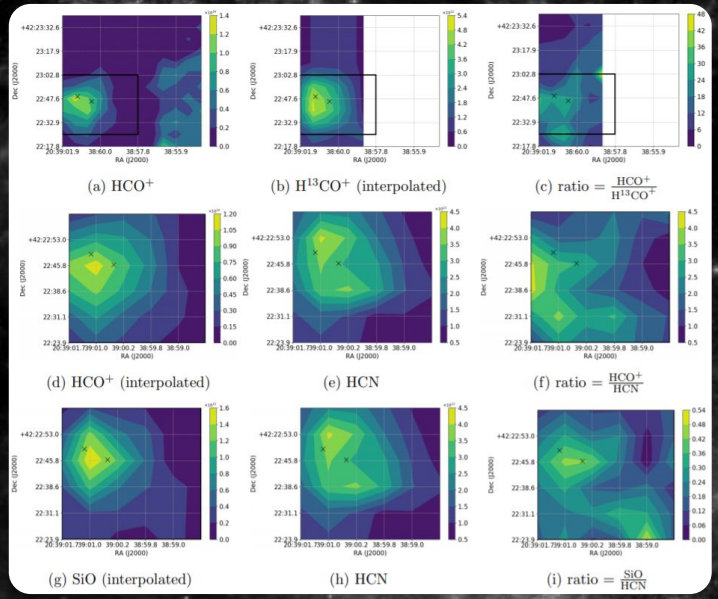

Figure 1: DR 21(OH) column density ratio maps. The left (center) column gives the mean column density contour plot for the molecule in the numerator (denominator) in cm^{-2}. The right column gives the ratio map of the column densities.

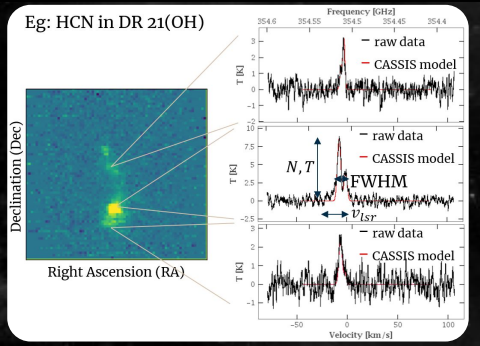

Figure 2: Intensity map of HCN in DR 21(OH) (left side) and sample spectra with CASSIS model fit in red (right side).

Results

We see evidence for self-absorption as well as indications of the outflow gas in the southeast direction. The 12C/13C ratio ranges between 15–25 across the source, and we also found evidence for the HII region south of DR 21(OH) to be impacting the abundance of HCO^+ through photodissociation.

Conclusion

We have created a framework in which to interpret future observations of WCCMs in HMSF regions. Such results can give insight into the physical factors that impact WCCC.

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The background image was produced using the "Aladin sky atlas".

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