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Spectral line surveys of evolved stars and protostars with the LMT

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Abstract. Spectral line surveys at limited spectral resolution towards star-forming regions and evolved stars have been possible with the Large Millimeter Telescope thanks to its redshift search receiver, which covers the frequency range from 73 to 111 GHz. Here we present a couple of examples showing the molecular content of objects in these two different stellar evolution phases.

Key words. Stars: abundances – ISM: molecules – ISM: abundances

1. Introduction

Among the maser species found in star-forming regions, the class I methanol masers stand out because of it relations with shocked environments (see, e.g. Menten 1996). In a series of papers, we have studied at high-angular resolution (few arcsec) the distribution of the class I methanol maser transition at 44 GHz with the VLA (Kurtz et al. 2004; Gómez-Ruiz et al. 2016; Rodríguez-Garza et al. 2018). In the present study we prove the molecular content around the detected maser spots.

On the other extreme of the stellar evolution, a particular class of outflow present molecular emission at radial velocities of a few hundred km s^{-1} (see, e.g. Gómez-Ruiz et al. 2017). These are the so-called extreme outflows of protoplanetary nebulae. Given the fact that these objects have been predominantly studied in CO, in this work we present information of other molecules present at such velocities in this kind of objects.

2. Observations

The observations were performed with the Redshift Search Receiver (RSR; Erickson et al. 2007) on the Large Millimeter Telescope *Alfonso Serrano* (LMT; Hughes et al 2010), during several nights in 2016, when the telescope had a surface of 32 meter in diameter. The RSR covers the frequency range from 73 to 111 GHz at an spectral resolution of 31 MHz, which provides a velocity resolution of about 100 km s^{-1} at the center of the band. The angular resolution at the frequencies of the detected molecules varied from $\sim$ 21 to 27 arcsec. The data was reduced with a custom made

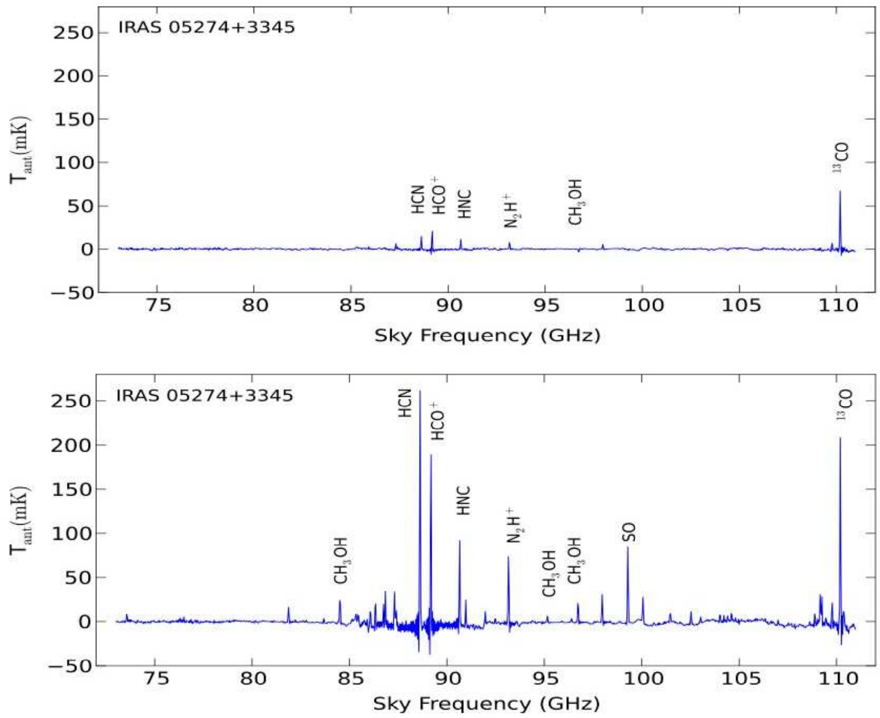

Fig. 1. LMT/RSR spectra of the central region (upper panel) and maser spots in protostellar object IRAS 05274+3345 (Rodríguez-Garza et al. 2018) .

software called DREAMPY and later analyzed with other tools.

A total of 38 high-mass star formation regions were selected from the VLA maser surveys of Gómez-Ruiz et al. (2016) and Rodríguez-Garza et al. (2018), while three protoplanetary nebulae with known CO outflows were chosen for LMT/RSR observations.

2.1. Results

Many lines were detected at all positions observed in the class I methanol maser regions. The density of spectral lines is notably higher in the shocked gas than in the central regions (see Fig. 1). Partial results of the survey have been presented by Rodríguez-Garza et al. (2018). Of particular relevance has been the finding of the 84 GHz class I methanol maser transition, that has been poorly covered by previous surveys (Breen et al. 2018).

Extreme high-velocity emission from the protoplanetary nebulae outflows was found in several molecules, such as SO, SO_2, SiO, HCN, and ^{13}CO (see Fig. 2). The SiO and SO molecules we found with the highest abundances. The results of IRAS 16342−3814 were presented in Gómez-Ruiz et al. (2017), and the rest of the sources will be presented elsewhere.

3. Conclusions

The masers spots have shown to be reach in molecular transitions, with tentative identification of complex organic molecules. High angular and spectral resolution observations are needed to confirm the presence of these molecules within the shocks.

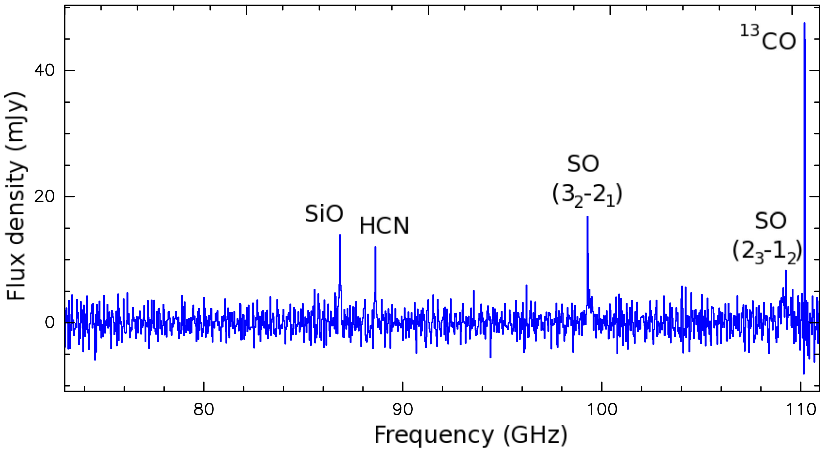

Fig. 2. LMT/RSR spectrum towards protoplanetary IRAS 16342 (Gómez-Ruiz et al. 2017) .

In the extreme outflows of protoplanetary nebulae we found several molecules which are apparently abundant is this high-velocity regime. Sampling more sources would help to understand the chemical richness of this component that may be related to jet structures.

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