A sensitive spectral survey of Orion KL at wavelengths between 6 and 7 mm

J. R. Rizzo (Centro de Astrobiología), B. Tercero, and J. Cernicharo (Instituto de Ciencias de Materiales de Madrid)

About Orion KL

The Orion KL source has been widely recognized as a close and well-known star-forming region, and one of the richest molecular clouds known in our Galaxy. It hosts newly formed protostars, with strong interaction between outflows and their accretion disks. It results in a series of complex chemical processes currently carrying out. Indeed, this is the only where very molecular species have been discovered for the first time (see e.g. the methanol maser in Tercero et al. 2003).

In a very small area, it is possible to identify at least four well-known components in this source: a hot core, a compact ridge, and a plume, all of them immersed within the ambient cloud (the extended ridge).

The Orion KL region is therefore an excellent tested for the search of new molecules and also for the characterization of those already known.

The survey

A sensitive spectral survey of Orion KL, one of the few clouds available at the NASA’s Madrid Deep Space Communications complex, has been completed in a sensitive spectral survey of Orion KL in the frequency range from 6.1 to 6.8 mm. The observations were carried out using the 30m IRAM telescope.

We used the new 8-band cooled receiver, which has an appropriate temperature of 4K. The back-end employed was the Microsoft Parkes Universal Processor (MUPR), which provides 1.5 Gs of instantaneous bandwidth, with a resolution of 188 MHz, for each circular polarization.

The survey was conducted in position switching mode in six sub-bands, with a superposition of 184 MHz between two consecutive sub-bands, in order to check consistency and eliminate possible image band effects.

Total integration time was 1460 minutes (i.e. 24 hours). Each sub-band integration time varied from 87 to 422 minutes, in order to keep a uniform rms of about 6 mK, on a main beam scale.

Results

The figure on the left shows the resulting spectrum. The upper panel displays the full range both in frequency and in intensity. We see that the 6-7mm spectrum is dominated by the emission of SiO masers and RRLs; some simple molecules (CS, H2CO, HCN, methanol) also appear, traces of low density and cold gas.

The middle panel depicts a zoom in intensity, where it is possible to distinguish a number of other, more complex molecules, particularly SO2, CH3CN, CH3ODON, and OCS. As we see in the model, these molecules are associated to the hotter parts of the region.

The three lower panels are spectral windows (indicated in green in the middle panel) which display the richness of spectral lines, as well as the varied morphology. More than 200 spectral lines have been identified, corresponding to 39 species.

The model

A total of 258 lines have been identified. Besides the RRLs, these lines correspond to 20 different molecular species -25 species when considering different isotopologues and vibrational states-. Neither the SiO masers nor HNMs have been included in this model.

The 7mm model is also based on the result of the fitting of some species at 3, 2, and 1.3 mm, detected in a recent survey using the IRAM 30m radio telescope (Tercero et al. 2010, Daly et al. 2013, Esplugues et al. 2013b, López et al. 2014). These species are CH3CN, CH3CON, “C0’, “C1’, and “C2’. All these species, except HCN, mainly emit from the hottest component of this source (the hot core, at T~250 K).

We also noted a significant lack of emission from the coldest region (the extended ridge, at ~40-60 K).

Concluding remarks

A survey of the Orion KL region, in the almost unexplored range from 6 to 7 mm in wavelength, we have been able to detect the multi-line spectrum of over 250 transitions from 20 molecules. The total number of molecular species, after considering different isotopologues and vibrational excited states, grows up to 35.

Some complex organic molecules, such as CH3CN and CH3CN, arise from the hot core; CH3NL and CH3CN are probably in the same group, but are close to the detection limit.

Most of the other molecules seem to arise from the coldest parts of the source, with surprisingly high column densities.

21 spectral lines remain unidentified (U-lines).

Therefore, the range from 6 to 7 mm (6-band) is a valuable electromagnetic window to pursue chemical studies which complement those at higher frequencies.

Bibliography

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