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Pilot program with the LMT to look for molecules in Planetary Nebulae

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Abstract. Understanding the molecular content of planetary nebulae (PNe), and how it varies with the progenitor age, its mass and other properties, is very important to find out the underlying chemistry of these objects. Young PNe present a significant number of molecular species. Maser-emitting PNe are in the earliest phases of PN formation, therefore these sources are key objects to study the molecular content during the early evolution of PNe. The survival of molecules in PNe shells have been the subject of debate for several years. It has been suggested that dusty cometary-knots could shield the molecular material, and preserve it through the evolution of proto-PNe into PNe. We propose a pilot program with the Large Millimeter Telescope (LMT) to look for high-density tracers, such as: HCN and HCO^+ in PNe that may arise from dense clumps, which provide a shielding mechanism to protect the molecules, and study their fractional abundances with the PN age.

Key words. ISM: molecules – stars: abundances – planetary nebulae: general

1. Introduction

The circumstellar envelopes around evolved stars are an active site for the production of molecules. Currently, over 20 molecular species have been discovered in PNe (Zhang 2017). Several young PNe, such as NGC 7027 and NGC 6537, have been studied (Zhang et al. 2008; Edwards & Ziurys 2013). These objects appear to have a notable chemical inventory, with species such as: CN, HCN, HNC, CCH, CS, SO, H_2CO, HCO^+, N_2H^+.

Recently, HCN and HCO^+ were detected in thirteen of the seventeen PNe with ages range from 800 to 13 000 yr (Schmidt & Ziurys 2016). Nine of them were common to both molecules. The abundances of these species were found to remain relatively constant with nebular age over a 10 000 yr time span, in contrast to predictions of chemical models.

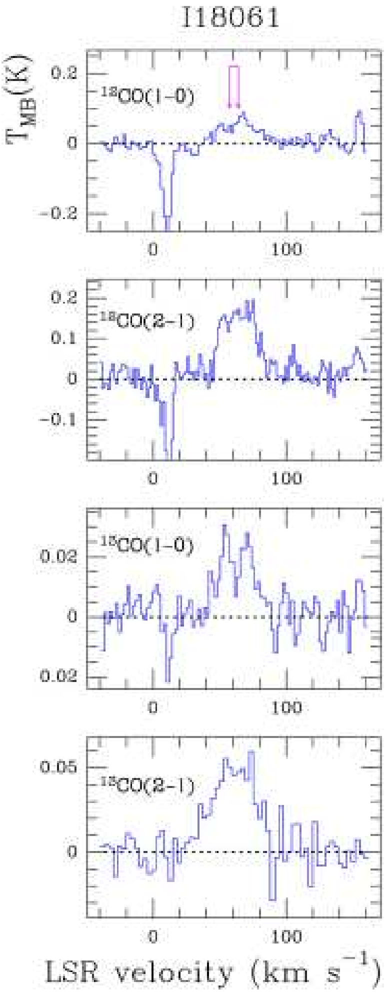

Fig. 1. ^{12}CO and ^{13}CO spectra showing both transitions $J = 1 \to 0$ and $2 \to 1$ towards a maser-emitting PN, IRAS 18061−2505 (I18061). The magenta arrows indicate the LSR velocities of the H_2O maser features (Uscanga et al. 2019).

2. Proposed observations and goals

We propose to carry out a mm molecular line survey of four maser-emitting PNe, they could be in their earliest phases of formation. We have previously detected ^{12}CO and ^{13}CO toward three of them using the IRAM 30m telescope (see Fig. 1, Uscanga et al. 2019). We plan to use SEQUOIA that cover a frequency range 85−115 GHz at the LMT.

Maser-emitting PNe are key objects to study the molecular content during the very early evolution of PNe. The main goals are the following:

– Study the molecular content of PNe with maser emission. Measuring the fractional abundances of HCN and HCO^+ and comparing with those values expected for more evolved PNe (Schmidt & Ziurys 2016).
– Investigate the survival of molecules in the shells of PNe, which has been subject of theoretical debate for many years.
– Observe these specially young PNe, given the lack of molecular surveys focusing on them. Until now, K3-35, is the only maser-emitting PN where HCO^+ has been observed and detected (Tafoya et al. 2007).
– Test the capabilities of the 50m LMT, showing that it is possible to detect molecular emission associated with small angular sources with single-dish observations.

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