Planetary Nebulae: An Eye to the Future
Proceedings IAU Symposium No. 283, 2011
A. Manchado, L. Stanghellini & D. Schönberner, eds.

doi:10.1017/S1743921312012045

A complete survey of mm line emission from CO and ^{13}CO in water fountain stars

J. Ricardo Rizzo[1], José F. Gómez[2] Luis F. Miranda[3], Mayra Osorio[2] and Olga Suárez[4]

[1]Centro de Astrobiología (INTA-CSIC), Torrejón de Ardoz, Spain
email: ricardo@cab.inta-csic.es

[2]Instituto de Astrofísica de Andalucía (CSIC), Granada, Spain
email: jfg@iaa.es, osorio@iaa.es

[3]Departamento de Física Aplicada, Universidad de Vigo, Vigo, Spain
email: lfm@iaa.es

[4]Laboratoire Fizeau, Université de Nice Sophia Antipolis, Nice, France
email: olga.suarez@unice.fr

Abstract. "Water fountains" (WF) are post-AGB stars characterized by very fast and often bipolar jets in the water maser line at 22 GHz. We conducted a survey of the CO and ^{13}CO line emission using the IRAM 30m radio telescope of all the sources visible from the observatory. Over a total of 10 WFs observed, we identified CO and ^{13}CO associated to IRAS 18460-0151 and IRAS 18596+0315. As the CO line emission is ubiquitous in the Galactic plane, the confirmed detections have met strict criteria to consider these cases as confirmed detections. The velocity components associated to the WFs are $\sim 40\,\mathrm{km\,s^{-1}}$ wide, centered at the star velocity, present only at the star position, and detected in the four observed transitions, the CO and ^{13}CO $J = 1 \rightarrow 0$ and $2 \rightarrow 1$ lines. A preliminary study, based on line ratios, indicates that this molecular component has a high opacity, and a very low ^{12}C/^{13}C isotopic ratio.

Keywords. circumstellar matter, stars: evolution, ISM: molecules, masers

---

Water fountain stars (WFs) are evolved objects whose main feature is a highly widespread emission in the 22 GHz water maser line (Imai 2007). When observed through inteferometers, multiple components in the water spectra show clear bipolarity and, in some cases, grows up to 500 $\mathrm{km\,s^{-1}}$ (Gómez *et al.* 2011). This emission is thought to be associated to bipolar outflows emerging from the circumstellar envelopes (CSE); therefore, we are probably seeing in these objects the first stages when the nebulae morphologies changes from spherical to bipolar. Almost nothing is known about the CSE present in WFs. Until this work, the only case studied is IRAS 16342-3814, where Imai *et al.* (2009) and He *et al.* (2008)) reported the detection of CO emission. Their findings are compatible with a spherical wind of $\sim 20\ \mathrm{km\,s^{-1}}$, and a mass loss rate of about $10^{-5}\ \mathrm{M_\odot\,yr^{-1}}$.

Using the 30m radio telescope at Pico Veleta, we surveyed of all the WFs visible from the site; the aim of the survey is to provide a first statistics about the detectability of CO in these sources, and proceed to analyze the positive cases. The observations were carried out in two different runs in 2009 and 2010, using the EMIR receiver and the VESPA autocorrelator. The $J = 2 \rightarrow 1$ and $1 \rightarrow 0$ lines of CO and ^{13}CO have been observed. As the low-J CO transitions are dominated by Galactic general emission, we implemented a 5-points strategy, which consisted in the observation towards the star position, and towards four points, N, S, E and W, 24$''$ apart.

Emission in eight out of 10 sources have been detected. However, two cases are reported as having line emission associated to the WFs: IRAS 18460+0151 and IRAS 18596+0315. Theses sources show velocity components present only at the star position, in three or four

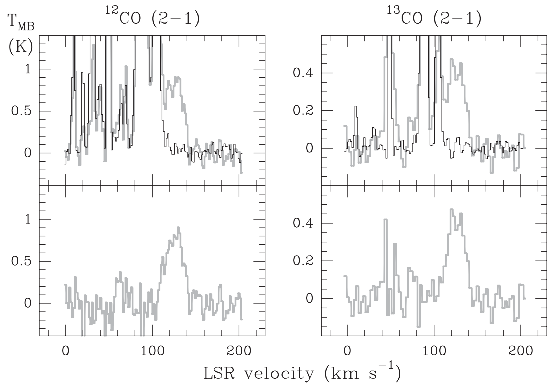

Figure 1. CO and ^{13}CO $J = 2 \rightarrow 1$ spectra towards IRAS 18460-0151. *(upper panel)* the spectra towards the star (grey) and the outside positions averaged. *(lower panel)* difference between both spectra. The wide velocity component is clearly noted, present only at the star position.

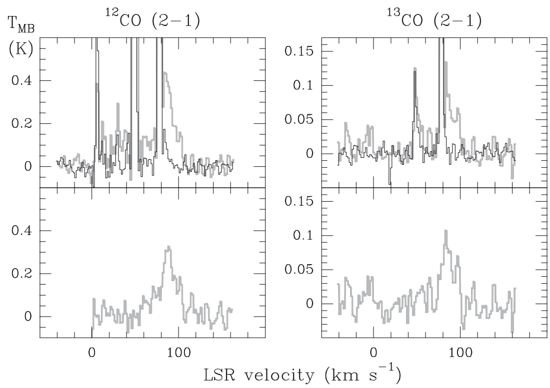

Figure 2. The same as Fig. 1, but for IRAS 18596+0315.

of the observed lines, and centered at the star velocity. Provided the unusual linewidths of these components, $\sim 40\,\mathrm{km\,s^{-1}}$, we think that these CO and ^{13}CO emission arise from the CSEs of the referred sources.

In Figs. 1 and 2, the CO and ^{13}CO $J = 2 \rightarrow 1$ spectra of the positive cases are depicted. Upper panels show the spectra towards the stars (grey) and the average of the outside positions. The bottom spectra show the difference, e.g. the star spectrum subtracted from the outside ones. The wide components are clearly noted.

We have performed a LVG analysis, and derived in both cases a very high opacity of the CO, a kinetic temperature above 50 K, and a very low ^{12}C/^{13}C isotopic ratio, consistent with the evolutionary status of these objects. Computation of the mass losses provides values $> 10^{-5}$ M$_\odot$ yr^{-1}.

These results encourage new searches using more sensitive observations and higher angular resolutions. Another natural follow up to these results is also to start a study of other chemical compounds, as well as the search for other, undiscovered WFs.

References

Gómez, J. F., Rizzo, J. R., Suárez, O., *et al.* 2011, *ApJL*, 739, L14
He, J.-H., Imai, H., Hasegawa, T. I., *et al.* 2008, *A&A*, 488, L21
Imai, H. 2007, *IAU Symp.*, 242, 279
Imai, H., He, J.-H., Nakashima, *et al.* 2009, *PASJ*, 61, 1365

https://doi.org/10.1017/S1743921312012045 Published online by Cambridge University Press