Astrophysical Masers:
Unlocking the Mysteries of the Universe
Proceedings IAU Symposium No. 336, 2017
A. Tarchi, M.J. Reid & P. Castangia, eds.
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doi:10.1017/S1743921317009553

Missing flux in VLBI observations of SiO maser at 7 mm in IRC+10011

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Abstract. VLBI observations of SiO masers recover at most 40-50% of the total flux obtained by single dish observations at any spectral channel. Some previous studies seems to indicate that, at least, part of the lost flux is divided up into many weak components rather than in a large resolved emission area. Taking benefit of the high sensitivity and resolution of the HSA, we investigate the problem of the missing flux in VLBI observations of SiO maser emission at 7 mm in the AGB stars and obtain a high dynamic range map of IRC+10011. We conclude that the missing flux is mostly contained in many very weak maser components.

Keywords. stars: AGB and post-AGB, instrumentation: interferometers, masers.

1. Introduction

VLBI observations of SiO masers are providing extremely valuable information on the inner circumstellar shells around AGB stars, the regions where dust grains are not yet formed and mass ejection originates, after a complex pulsational dynamics. These data are also very useful to understand the pumping mechanisms responsible for this widespread emission in AGB envelopes. The J=1–0 maser lines (in the v=1 and v=2 vibrationally excited states), at 7 mm wavelength, systematically yield ring-like flux distributions, with diameters of about 10^{14} cm (equivalent to a few stellar radii, see Diamond *et al.* 1994, Desmurs *et al.* 2000).

One of the main problems that persists in the study of the circumstellar SiO masers is the significant amount of flux lost when long baseline interferometry observations are performed. For 7 mm lines, up to about one half of the line emission is usually lost, as it is also the case at 3 mm (see Colomer *et al.* 2017), a problem that is not present in VLA observations. This missing flux could be due to over-resolution, i.e. when the emission is produced on larger scales than those corresponding to the shortest projected baselines of the array. However, another possible explanation could be that this missing flux, or at least part of it, consists of a multitude of compact but weak undetected maser components (at the noise level of the resulting map).

2. Observations

To check if part of the missing flux is contained in many very weak maser components (see Soria-Ruiz *et al.* 2004) or not, we took advantage of HSA capabilities at 7 mm that give a better UV-coverage, higher sensitivity and higher resolution. We observed in dual circular polarization with a velocity resolution (i.e. channel width) of 0.2 km/s and a total velocity coverage of about 55 km/s. Using all VLBA antennas, the VLA, the GBT and Effelsberg, we obtained maps of IRC+10011 of the two ^{28}SiO transitions v=1 and v=2, J=1–0 with a high spatial resolution and a high dynamic range (see Fig. 1).

https://doi.org/10.1017/S1743921317009553 Published online by Cambridge University Press

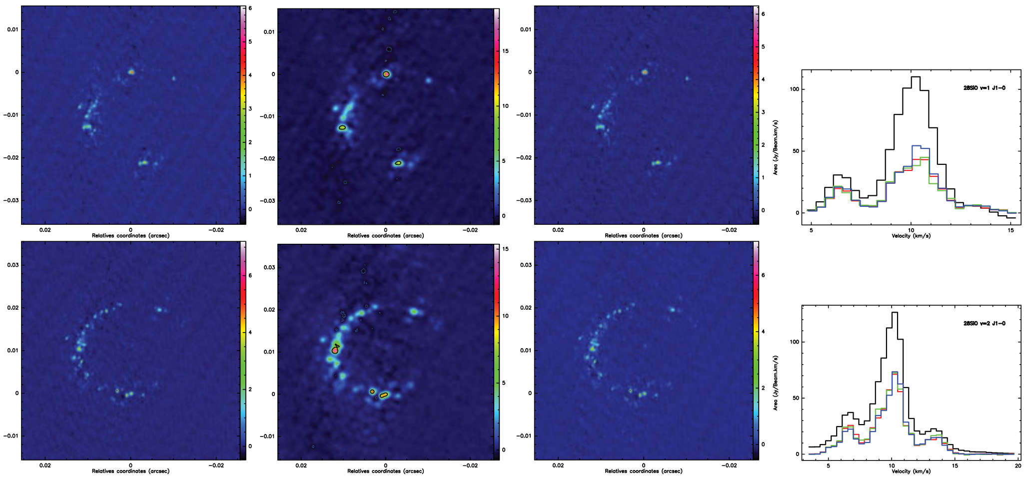

Figure 1. *Top* ^{28}SiO v=1, J=1–0 (at 43.122 GHz) transition and *Bottom* ^{28}SiO v=2, J=1–0 (at 42.820 GHz) transition. From left to right, maps of the two maser transitions obtained respectively with, case A, the full HSA array with full sensitivity and spatial resolution (baselines up to ∼10500 km, restoring beam 0.2 mas), case B, with a subset of antennas forming a very sensitive short array (with baselines <2500 km) and, case C, with all HSA antennas (and full sensitivity) but with a degraded restoring beam of 1 mas (low resolution). At right, flux density comparison between the autocorrelation flux intensity of the reference antenna used for the flux calibration (black line) and the integrated flux recovered in the maps in case A (red line), in case B (green line), and case C (blue line).

3. Preliminary results

Our preliminary results tend to show very similar results for the proportion of missing flux measured in these observations and in previous works. About half of the flux is still missing! The high sensitivity, we reach an rms of about 5 mJy/beam per channel for ^{28}SiO v=2, J=1–0, and high resolution of HSA (∼0.2 mas) do not allow us to significantly recover a higher percentage of flux. Moreover, either using the full spatial resolution of HSA with baseline of up to 10500 km or a compact array with baselines shorter than 2500 km (including short baseline highly sensitive VLBA-PT/VLA), do not significantly change this result. Even degrading the resolution (using a restoring beam 5 times larger), the small flux increase measured in a couple of channels (@ 10-11 km/s) for the v=1 map and corresponding to the arc like structure seen on the east side of the map is not significant, there is no difference in the recovering flux. Our main idea to explain these results is that the missing flux must be spread in a multitude of weak components undetected in our observations.

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https://doi.org/10.1017/S1743921317009553 Published online by Cambridge University Press