What is happening to IRAS 15103-5754 ?

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Abstract

We present radio observations of water masers toward the planetary nebula (PN) IRAS 15103-5754 (I15103), obtained during several campaigns at the Australia Telescope Compact Array (ATCA) and the Parkes antenna. I15103 is one of the rare planetary nebulae (PNe) exhibiting water maser emission. The follow-up of water masers is crucial in PNe, since the lifetime expected for this emission is very short, and it might trace the youngest stages of a star in the PN phase. The maser components detected in this source trace a jet with possible precession, which could be shaping its circumstellar envelope. Extraordinarily bright water maser emission reaching 1600 Jy was observed during our last observation campaigns, making I15103 the PN with the most intense water maser emission ever detected. The rapid evolution of its radio continuum emission associated to this unusual water maser activity indicates that this source could be one of the youngest PN known up to now.

Introduction

Water fountains are evolved stars showing water masers with components at high velocities (on the order of 100 km/s or larger). They may play an important role in the study of the shaping of PN, since they represent one of the first manifestations of collimated mass-loss in evolved stars.

It has been proposed that water fountains evolve into water-maser-emitting planetary nebulae, H_2O-PNe (Suárez et al. 2009). The latter type of objects, also recently discovered, allow us to investigate the result of the carving of the circumstellar envelope by the jets of the water fountains.

IRAS 15103-5754 (hereafter I15103) has been recently revealed as the first planetary nebula (PN) harbouring water masers with high expansion velocities ~ 80 km/s (Suarez et al., 2012).

I15103: a peculiar Planetary Nebula

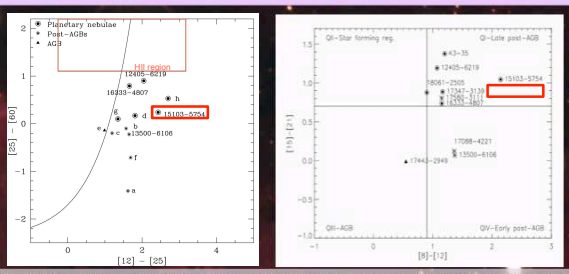
I15103 is an **atypical PN**, highly obscured at visible wavelengths and that does not show the classical optical lines characteristic of standard PN.

The reasons to **affirm** that I15103 is a **PN** are the following:

- The IR morphology is consistent with a bipolar PN
- The [NeII] line present in its IR spectrum is a sign of photoionization
- I15103 is located in the IR two-colour diagrams (IRAS and MSX) in the region populated by PNe

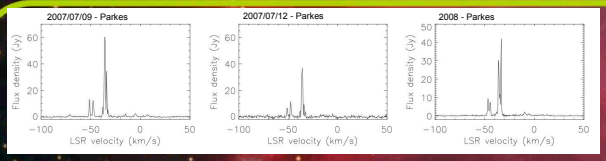
We can rule out I15103 as a Young Stellar Object since:

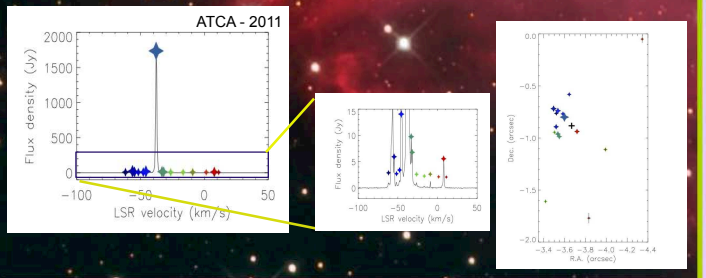
- There is a NH_3 clump, detected in the HOPs survey (Purcell et al. 2012) at 2arcmins from the source with v_{LSR} -40 km/s (not coincident with the stellar velocity of I15103 ~22.9 km/s). I15103 is outside the clump
- CS and ^{13}CO lines observed towards this source using single dish (Mopra-Australia) are centered at v_{LSR} -40 km/s → associated with the cloud showing NH_3 (RMS survey-Lumsden et al. 2013)
- If it were a YSO outside its parental cloud, it should be optically visible (not the case!)



IRAS (a) and MSX (b) two-colour diagrams from Suárez et al. 2009. The location of the post-AGB and PNe with water masers detected by these authors is shown.The letters correspond to the following sources: a. IRAS 07331+0021, b. IRAS 16552-3050, c. IRAS 17088-4221, d. IRAS 17347-3139, e. IRAS 17443-2949, f. IRAS 17580-3111, g. IRAS 18061-2505 h. K3-35.
The zone of the IRAS colour-colour diagram corresponding to HII regions is marked on the figure (Chan & Fich, 1995)

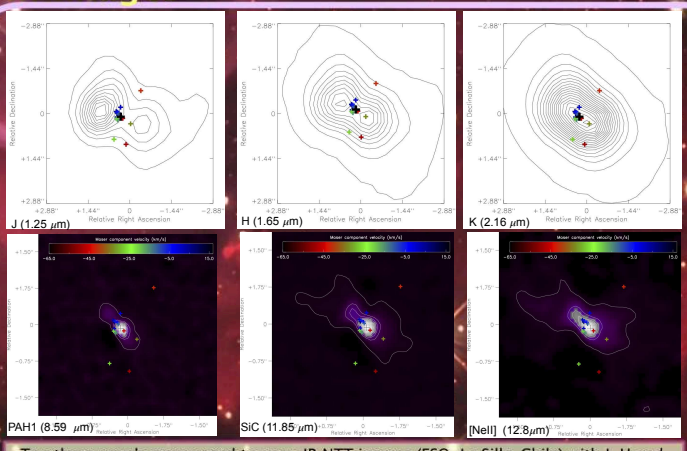
Temporal evolution of H_2O Masers





Water maser spectra obtained with Parkes (ATNF, Australia) in 2007-2009 (top three panel) and with ATCA (ATNF, Australia) in 2011 (bottom panel). The spatial distribution of the maser components is also shown (bottom right), with the same colour code for the maser velocity. The increase in intensity of the strongest maser component between 2008 and 2011 is a factor of 300. This makes of I15103 the most energetic maser ever observed in an evolved star. Several scenarios can ben envisaged for such an increase :
a) An increase in the energy input from the star, which yielded a higher density of inverted molecules
b) A change in the jet orientation (e.g., precession), resulting in a more favorable orientation, with a longer path of velocity-coherent inverted molecules along the line of sight

IR Images



Top three panels correspond to near-IR NTT images (ESO, La Silla-Chile) with J, H and K filters (Ramos-Larios et al. 2012).

Bottom panels correspond to mid-IR VISIR/VLT images (Eso, Paranal-Chile) with PAH1, SiC and [NeII] filters (Lagadec et al. 2011).

Water maser components are over-plotted on all images. The position of the radio continuum emission has been marked with a black cross. The LSR velocity of the central star is -22.9 km/s. Note the difference in scale of both sets of images.

The most blue-shifted masers are aligned with the radio continuum and with one of the redshifted masers, showing a bi-directional jet aligned precisely with the lobes observed in the IR. This high-velocity jet can be carving the cavities that form the PN. Masers with intermediate velocities (green) could track a torus that could be the responsible for the high extinction of the star at optical wavelengths.

Conclusion

I15103 is the first PN showing water masers with high velocity components. This makes this source the first water fountain - PN. It can represent the evolutionary link between post-AGB water fountains and H_2O-PNe, where masers do not show high velocity components.
The jet traced by the water masers is aligned in the direction of the lobes observed at IR wavelengths, showing that similar jets could be the shaping agent of the lobes.
The high variability in the flux density of the maser components makes the future monitoring of this source important, since its variability could trace the evolution of the mass-loss energetics

Bibliography

- Chan & Fich, AJ, 109, 2611 (1995)
- Lagadec et al., MNRAS, 417, 32 (2011)
- Lumsden et al., ApJS, 208, 11 (2013)
- Purcell et al. MNRAS, 426,1972, (2012)
- Ramos-Larios, et al., A&A, 545, 20 (2012)
- Suárez et al., A&A, 505, 217 (2009)
- Suárez, et al. IAU Symposium,287, 230 (2012).