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Water fountains and H_2O-PNe as seen by VISIR/VLT

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Abstract

We present mid-infrared images obtained with VISIR on the VLT for a sample of water fountain stars or PNe harbouring water masers (H_2O-PNe). The extremely good weather conditions during the observations have led us to obtaining the highest quality images of the dust emission from these objects available up to now. In addition, resolved images for four of these objects are presented here for the first time. All the objects are clearly bipolar or multipolar, and most of the images reveal the presence of dusty disks or torus and jets that are sculpting the nebula and that are also traced by the water masers. Some of these jets show clear evidences of precession, indicating that the shaping could be due to the presence of a binary system.

Introduction

Water fountains are evolved stars showing water masers with components at velocities larger than 100 km/s. They play an important role in the study of the shaping of PN, since they represent the first manifestation of collimated mass-loss in these types of stars.

Water fountains are believed to evolve into Planetary Nebulae that harbour water masers, H_2O-PNe (Suárez et al. 2009). These interesting objects, also recently discovered, allow us to investigate the result of the carving of the circumstellar envelope by the jets of the water fountains.

Only two out of the 12 water fountains and two out of the five H_2O-PNe reported up to now, are known to be visible at optical wavelengths. This sets the IR imaging as the optimal way to study the morphology of these interesting objects.

Observations and data reduction

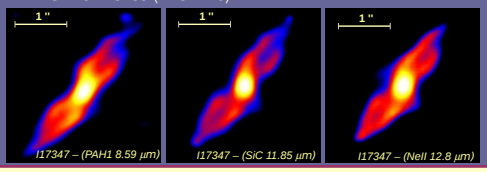
The observations were taken in the mid-infrared with VISIR on the VLT (Lagage et al., 2004) in burst mode using 3 filters: PAH1 (8.59 µm, half band width 0.42 µm), SiC (11.85 µm, 2.34 µm) and NeII (12.81 µm, 0.21µm). The size of the pixel was of 0.075" and the field of view of 19.2x19.2". Only IRAS 17347-3139 was observed in the standard mode. The exposure time was 30s per filter. With the burst mode, all the single chopping and nodding images are recorded, allowing the reconstruction of quality-enhanced images using shift and add techniques. The images were deconvolved using the method of maximum likelihood, applying between 60 and 100 iterations, depending on the source.

The log of the observations is shown in the table below. In addition, 5 other water fountains have been observed but have not been resolved: IRAS 18043-2116, OH12.8-0.9, IRAS 18286-0959, IRAS 18460-0151, IRAS 19134+2131.

Name	Classification	Filters	Date
IRAS 15103-5754	H_2O-PN water fountain	PAH1, SiC, NeII	2008-06-30
IRAS 15445-5459	Water fountain	SiC, NeII	2008-07-02
IRAS 16333-4807	H_2O-PN	PAH1, SiC, NeII	2008-06-30
IRAS 16342-3814	Water fountain	PAH1, NeII	2008-06-30
IRAS 17347-3139	H_2O-PN	PAH1, SiC, NeII	2008-05-26
W43A	Water fountain	SiC, NeII	2008-07-02

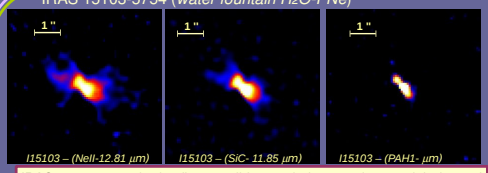
Results: individual objects

IRAS 17347-3139 (H_2O-PNe)



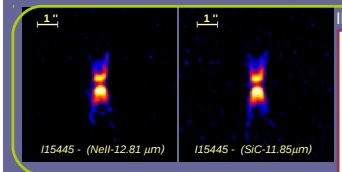
The water masers in this source are located in the center, close to the central star occupying a region of 0.2"x0.1", (de Gregorio et al. 2004) and they might trace the inner collimating disk. Four precessing jets are observed in the images at the three bands, tracing a global multipolar structure.

IRAS 15103-5754 (*water fountain H_2O-PNe*)



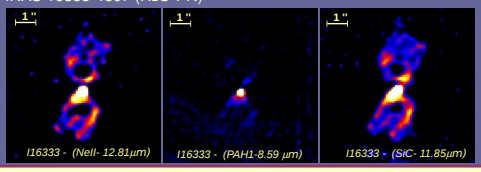
IRAS 15103-5457 is the first candidate to belong to the special class of H_2O-PNe that still show water fountain characteristics (Suárez et al. 2009). It might be one of the youngest PN known. The mid-IR images show a bipolar structure with a thick waist and with a horn shape in the outer part of the NE lobe. The distribution of the water masers is still unknown.

IRAS 15445-5459 (water fountain)



This source shows a bipolar structure with a dark waist that confine the bipolar outflows. Each one of this bipolar lobes is divided in two towards the outer part of the nebula.
The water masers components extend for 90km/s (Deacon et al. 2007), but their position is still unknown.

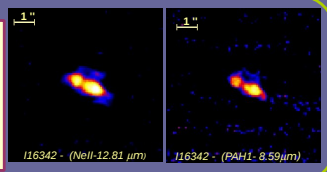
IRAS 16333-4807 (H_2O-PN)



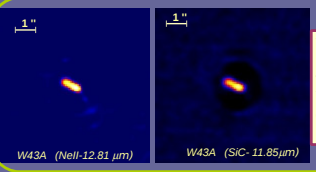
This source shows a bipolar structure with a butterfly shape and a thin dark waist collimating the bipolar lobes. A hole is seen in both lobes in the NeII and SiC filters, while the emission in the PAH1 is much fainter. Water masers show only one component (Suárez et al. 2009), and their position is still unknown.

IRAS 16342-3814 (water fountain)

This source has already been imaged at optical and IR wavelengths (Sahai et al. 1999, Verhoelst et al. 2009). Our mid-IR images show the same bipolar morphology as described by those authors.
The OH and H_2O masers are disposed along the bipolar lobes (Sahai et al 99)



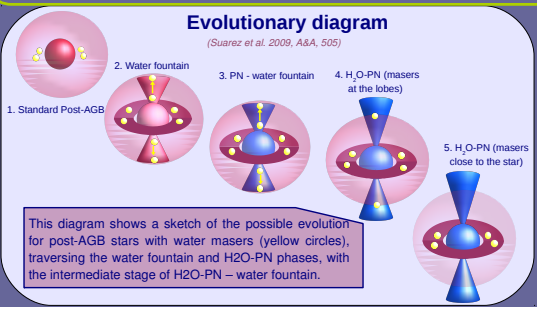
W43A (water fountain)



This source shows a bipolar structure with no signs of a dark waist.
The OH and H_2O masers are disposed along the bipolar lobes (Imai et al. 2002).

Evolutionary diagram

(Suarez et al. 2009, A&A, 505)



This diagram shows a sketch of the possible evolution for post-AGB stars with water masers (yellow circles), traversing the water fountain and H2O-PN phases, with the intermediate stage of H_2O-PN – water fountain.

Conclusions

The mid-IR images of the 2 H_2O-PNe, the 3 water fountains and the first water fountain-H_2O-PN show bipolar structures with dark waists in the majority of the cases. Signs of precession are witnessed in IRAS 17347-3139 and maybe also in IRAS 16333-4807, indicating the probable presence of a binary central star.

Bibliography

Deacon et al. 2007, ApJ, 658, 1096-1113
de Gregorio Monsalvo et al. 2004, ApJ, 601, 921-929
Imai et al. 2002, Nature, 417, 829-831
Sahai et al. 1999, ApJ, 514, L115-L119
Suárez et al. 2009, A&A, 505, 217-225
Verhoelst et al. 2009, A&A 503, 837-841