Cosmic Masers: Proper Motion toward the Next-Generation Large Projects
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Interferometric Observations of the Water Fountain Candidates OH 16.3−3.0 and IRAS 19356+0754

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Abstract. Water Fountains (WFs), located between the AGB and PN phases of stellar evolution, may provide significant clues on the shaping process of PNe. We present new VLA observations of the WF candidates OH 16.3-3.0 and IRAS 19356+0754. We detect H_2O and OH maser and radio continuum emission towards OH 16.3-3.0. We suggest that the OH maser emission of OH 16.3-3.0 is associated with an aspherical circumstellar envelope due to its spatio-kinematics and peculiar spectral profile. We could not confirm the candidates as bona fide WFs because of the narrow velocity spread (OH 16.3-3.0) or non-detection (IRAS 19356+0754) of H_2O maser emission. Further monitoring could help to discern their nature.

Keywords. masers, stars: AGB and post-AGB

1. Introduction

WFs are evolved stars with initial masses $< 8M_\odot$, most of which are in the post-AGB phase (Imai 2007; Desmurs 2012; Gómez *et al.* 2017). Their H_2O masers trace high-velocity collimated outflows with expansion velocities larger than those in the AGB phase, which are typically 10−30 km s^{-1} (Sevenster *et al.* 1997). This collimated mass-loss could be one of the first indications of a morphological change in the circumstellar envelopes of evolved stars (Imai 2007). OH 16.3−3.0 (OH16.3) (IRAS 18286−1610) and IRAS 19356+0754 (I19356) were considered as WF candidates because they showed larger velocities in their H_2O maser spectra than those of OH, based on single-dish observations (Yung *et al.* 2013, 2014). We selected these candidates because of their relatively low H_2O maser velocity coverage compared to the 15 WFs so far known. Here we present interferometric observations to confirm their WF nature.

2. Observations and Method

Our observations were carried out with the VLA in its A configuration in 2019. We observed simultaneously H_2O maser and radio continuum emission at 22 GHz.

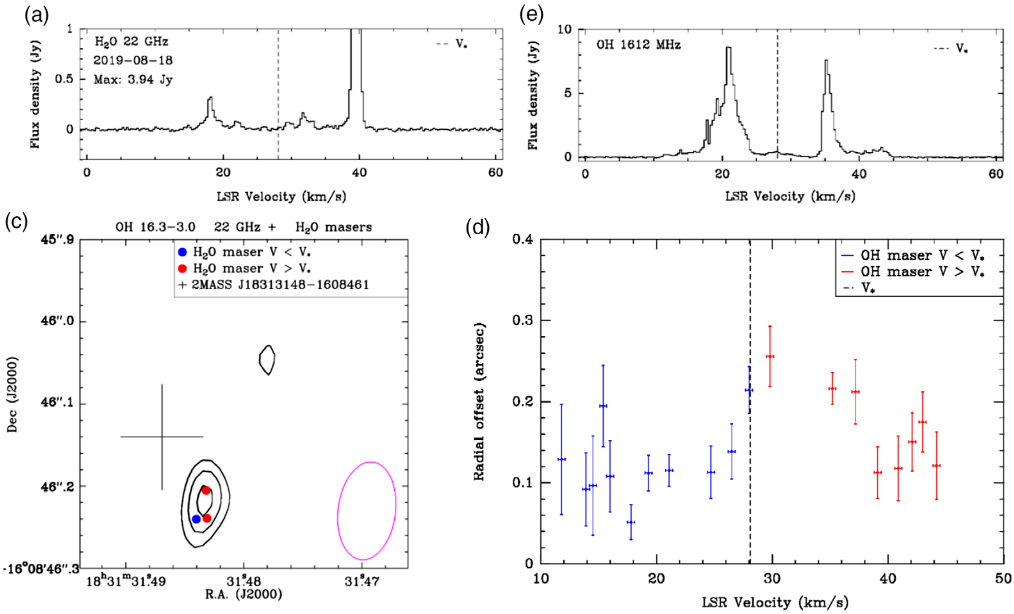

Figure 1. VLA observations toward the WF candidate OH16.3. (a) H_2O maser spectrum, zoomed in to better show the faint emission components. (b) OH maser spectrum. It shows a double-peaked profile with prominent wings. (c) Contour map of the radio continuum emission at 22 GHz. The contours are 3,4,5 times $1.3{\times}10^{-5}$ Jy beam^{-1}. The positions of the H_2O maser components are indicated by blue and red dots according to their velocities. The relative positional uncertainty between the H_2O masers is < 3.5 mas. The size of the cross of the 2MASS position indicates its 1σ position error. The magenta ellipse shows the synthesized beam. (d) V-R diagram of OH16.3. Since the stellar position does not coincide with the center of the spatial distribution of the OH masers, we considered the intensity-weighted emission centroid of the OH maser positions as the zero radial offset. The dashed lines indicate the assumed stellar velocity (V_*).

Moreover, OH maser observations at 1612 MHz were performed. Positions of the masers and continuum emission were obtained by 2-D Gaussian fitting. To explore the spatio-kinematics of the OH masers, we constructed a velocity-radius (V-R) diagram, where V is the LSR velocity, and R is the angular (radial) offset from the stellar position. To interpret this diagram, we considered a geometric model consisting of an AGB shell and a biconical, symmetric outflow (Fig. 2a in Zijlstra *et al.* 2001). This model is based on the interacting-winds scenario. The relationship between R and V is given by $R = R_{\rm shell}[1-(V-V_*)^2/V_{\rm exp}^2]^{0.5}$ (for details, see Zijlstra *et al.* 2001).

3. Results and Conclusions

In OH16.3, we detect H_2O maser emission with three distinct velocity components (with flux densities from 0.14 to 3.94 Jy, Fig. 1a), and unresolved radio continuum emission with a flux density of 0.07 mJy at 22 GHz (Fig. 1c). We also detect OH maser emission (Fig. 1b). This OH emission is expected to be associated with an aspherical circumstellar envelope because of: its peculiar OH maser spectrum profile (with prominent wings), the spatial distribution of its blue- and red-shifted masers overlapped in the plane of the sky (not shown here), and the deviations of an arc-shaped structure for a spherical AGB shell in its V-R diagram (predicted V-R relations for the geometric model can be found in Zijlstra *et al.* 2001) (Fig. 1d). OH16.3 may be a peculiar AGB or post-AGB star with a non-spherical wind. We note that the velocity spread of the H_2O

maser emission is smaller than that in OH, different from what was found on single-dish observations. The spatial distribution of the H_2O maser components (Fig. 1c) does not show conclusive evidence for a collimated jet. It is still possible that the source is a WF, but with the outflow lying close to the plane of the sky, or a different kind of WF, e.g., with a less massive progenitor or with a relatively younger age (Uscanga *et al.* 2019). We did not detect H_2O maser emission in I19356 with a 3σ detection limit of 17.7 mJy, despite a previous single-dish detection with a flux density of ~ 0.2 Jy and rms of 10 mJy (Yung *et al.* 2014). Further monitoring could help to discern the nature of these sources.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1743921323002168

References

Desmurs, J.-F. 2012, *Proc. IAU Symp.*, 287, 217
Gómez, J. F., Suárez, O., Rizzo, J. R., *et al.* 2017, *MNRAS*, 468, 2081
Imai, H. 2007, *Proc. IAU Symp.*, 242, 279
Sevenster, M. N., Chapman, J. M., Habing, H. J., *et al.* 1997, *Astron. Astrophys. Suppl. Ser.*, 122, 79
Uscanga, L., Gómez, J. F., Yung, B. H. K., *et al.* 2019, *Proc. IAU Symp.*, 343, 527
Yung, B. H. K., Nakashima, J.-I., Imai, H., *et al.* 2013, *ApJ*, 769, 20
Yung, B. H. K., Nakashima, J.-I. & Henkel, C. 2014, *ApJ*, 794, 81
Zijlstra, A. A., Chapman, J. M., te Lintel Hekkert, P., *et al.* 2001, *MNRAS*, 322, 280