

A Profile-based Approach to Finding New Water Fountain Candidates using Databases of Circumstellar Maser Sources

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Abstract. Water fountains (WFs) are thought to represent an early stage in the morphological evolution of circumstellar envelopes surrounding low- and intermediate-mass evolved stars. These objects are considered to transition from spherical to asymmetric shapes. Despite their potential importance in this transformation process of evolved stars, there are only a few known examples. To identify new WF candidates, we used databases of circumstellar OH (1612 MHz) and H₂O (22.235 GHz) maser sources, and compared the velocity ranges of the two maser lines. Finally, 41 sources were found to have a velocity range for the H₂O maser line that exceeded that of the OH maser line. Excluding known planetary nebulae and after reviewing the maser spectra in the original literature, we found for 11 sources the exceedance as significant, qualifying them as new WF candidates.

Keywords. Evolved stars, masers, post-AGB stars, AGB stars

1. Purpose of the research

The main purpose of this study is to search for new candidates for WFs (for WFs, see, e.g., [Imai 2009](#)) by cross-checking H₂O (22.235 GHz) and OH (1612 MHz) maser sources from databases of circumstellar maser sources. We then investigated the basic infrared properties of the selected sources having a larger H₂O maser velocity range $\Delta V_{\text{H}_2\text{O}}$ compared to ΔV_{OH} of the OH maser ([Yung et al. 2013](#)).

2. Methodology

First, we selected circumstellar maser sources in which both the H₂O maser at 22.235 GHz and the OH maser at 1612 GHz are detected. We then used WISE and other

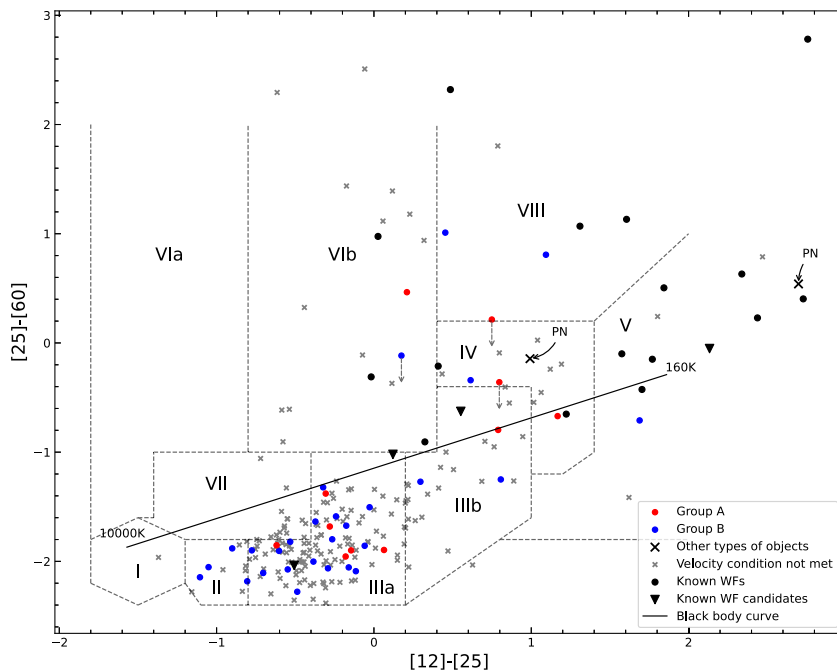


Figure 1. IRAS two-color diagram of 41 sources selected by the velocity condition $\Delta V_{\text{OH}} \leq \Delta V_{\text{H}_2\text{O}}$. This plot uses color indices defined as follows $[12] - [25] = 2.5 \log \left(\frac{F_{25\mu\text{m}}}{F_{12\mu\text{m}}} \right)$ and $[25] - [60] = 2.5 \log \left(\frac{F_{60\mu\text{m}}}{F_{25\mu\text{m}}} \right)$. For 11 sources the selection by the criterion is reliable (Group A), while for the rest verification is needed (Group B).

infrared archival images to remove possible YSOs. Finally, if the criterion $\Delta V_{\text{OH}} \leq \Delta V_{\text{H}_2\text{O}}$ is satisfied, then such maser sources were selected as candidates for WF. As a source of information on OH maser data, we used the database of [Engels & Bunzel \(2015\)](#) accessible from CDS/VizieR[†]. This database contains 8,474 OH 1612 MHz observations toward 2,195 sources. In the present analysis we used only the 1612 MHz line data. For the 22.235 GHz H₂O maser line, we used an unpublished database compiled by the same authors. The version 0.1 of the database used for our analysis contains records of 6,085 observations towards 3,642 sources.

3. Summary of initial results

From the cross-match between the OH and H₂O maser databases we extracted a sample of 229 sources with detections in both transitions. Comparison of their maser velocity ranges yielded 41 sources, which met the velocity criterion. From a detailed examination of the maser line profiles available in the literature, we concluded that the deviation of the H₂O maser velocity range was significant for 11 of the 41 initially selected sources (Group A in Fig. 1). The main results are as follows:

(1) We examined the IRAS colors of the samples and found that two of the 11 sources with a confirmed H₂O maser velocity deviation (IRAS 19069+0916 and IRAS 19319+2214) are in the color region for post-AGB stars. The H₂O maser profile of these sources are similar to that of known WFs.

(2) Of the 11 selected sources, six sources were located in the color region of the AGB stars. For two of the six sources (IRAS 19422+3506 and IRAS 22516+0838), the

[†] <https://cdsarc.cds.unistra.fr/viz-bin/cat/J/A+A/582/A68>

H₂O maser properties are different from those of typical AGB stars, and confirmation observations with radio interferometry are desired.

(3) We also confirmed the possibility that sources exhibiting the velocity deviation of the H₂O maser line could include astrophysically interesting sources other than WFs. Such objects could include, for example, peculiar planetary nebulae with maser emission and stellar merger remnants.

References

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