Interferometric Observations of the Water Fountain Candidates: OH 16.3-3.0 and IRAS 19356+0754

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IAU Symp. 380

Introduction

We present new interferometric observations with the Very Large Array (VLA) of the “Water Fountain” (WF) Candidates OH 16.3-3.0 (OH16.3) and IRAS 19356+0754 (I19356) [1,2]. WFs are low-mass evolved stars, most of which are in the post-AGB phase [3,4,5]. Their H_2O maser emission traces high-velocity collimated outflows (with expansion velocities larger than those in OH maser emission in the AGB phase, which are typically 10-30 km s^{-1} [6]) when observed at high-angular resolution. This collimated mass-loss could be one of the first indications of a morphological change in the circumstellar envelopes of evolved stars [3]. There are 15 WFs confirmed up to date [5]. Our aim is to characterize the WFs as a group to understand their role in the shaping process of planetary nebulae, looking for new sources. These WF candidates showed larger velocities in their H_2O maser spectra than in their OH maser spectra, based on single-dish observations [1,2].

Observations and Method

August 2019

We present simultaneous observations of H_2O maser emission and radio continuum at 1.3 cm carried out with the VLA in “A” configuration toward OH16.3 and I19356. Moreover, OH maser observations at 1612 MHz were performed.

Calibration was carried out with the VLA pipeline 2021.2.0.128 version implemented in CASA.

Our detection criteria were: for maser emission, a SNR ≥ 7 in ≥ 3 consecutive channels; for continuum emission at 1.3 cm, a SNR ≥ 3. Positions of H_2O and OH masers, and continuum emission were obtained by fitting 2D Gaussians.

We constructed a velocity-radius (V-R) diagram, where V is the LSR velocity and R is the angular offset (radial offset) from the stellar position. We considered a geometric model consisting of an AGB shell and a biconical, symmetric outflow. This model is based on the interacting-winds scenario [7].

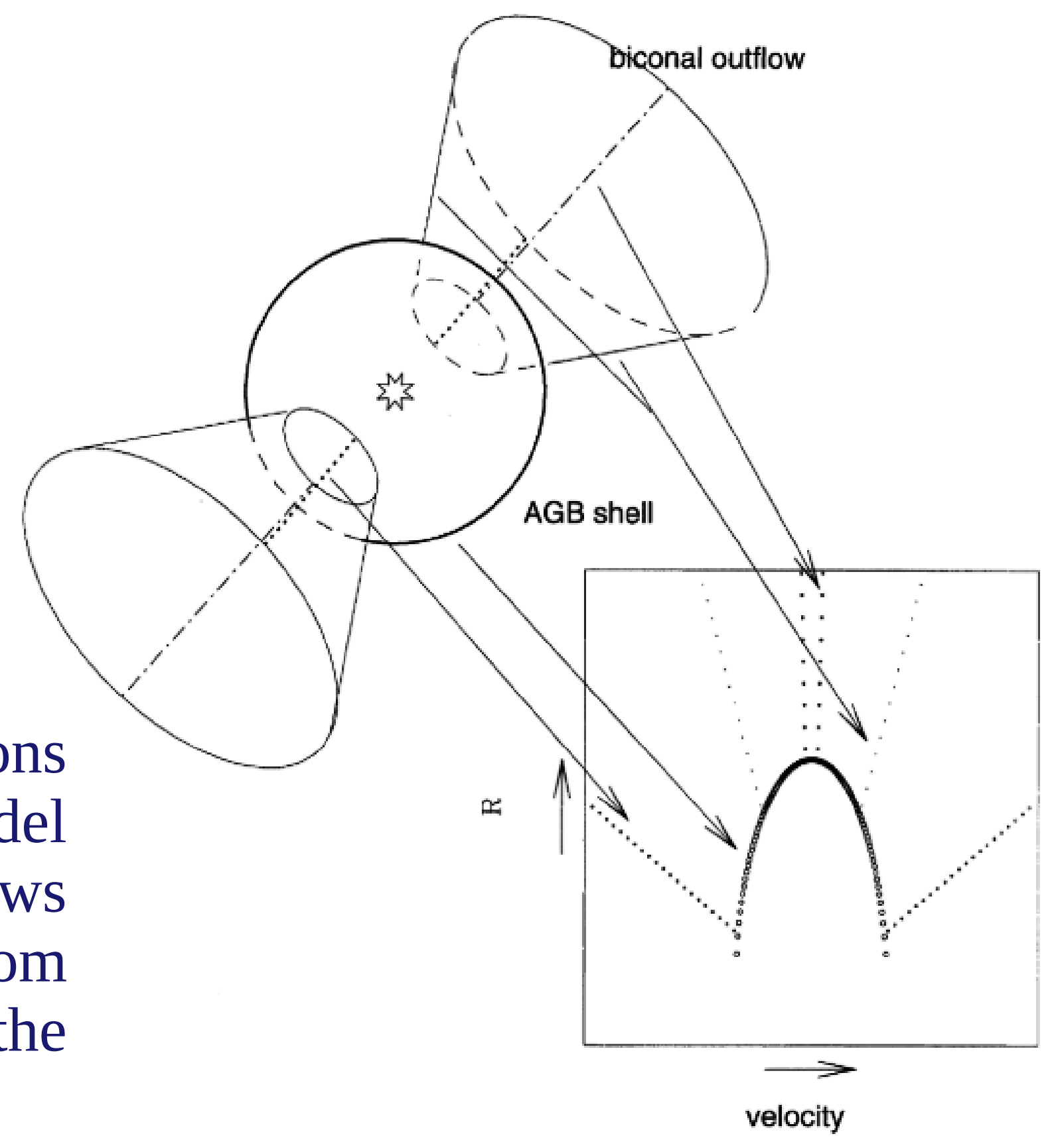

Fig. 1 Predicted V-R relations for the geometric model described above. The arrows indicate the contributions from the different locations in the model (Zijlstra et al. 2001).

References

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Acknowledgments

PC acknowledges support from Beca de Maestría of CONACYT (775363).
LU acknowledges support from Convocatoria de Apoyo a la Investigación Científica 2023 of the University of Guanajuato.

Results and Conclusions

In OH16.3, we detect H_2O maser emission at 22 GHz (Fig. 2) with three distinct components (with a spatial distribution shown as red and blue spots in Fig. 3), as well as radio continuum emission at 1.3 cm (black contours, Fig. 3) with a flux density of 0.066 ± 0.024 mJy.

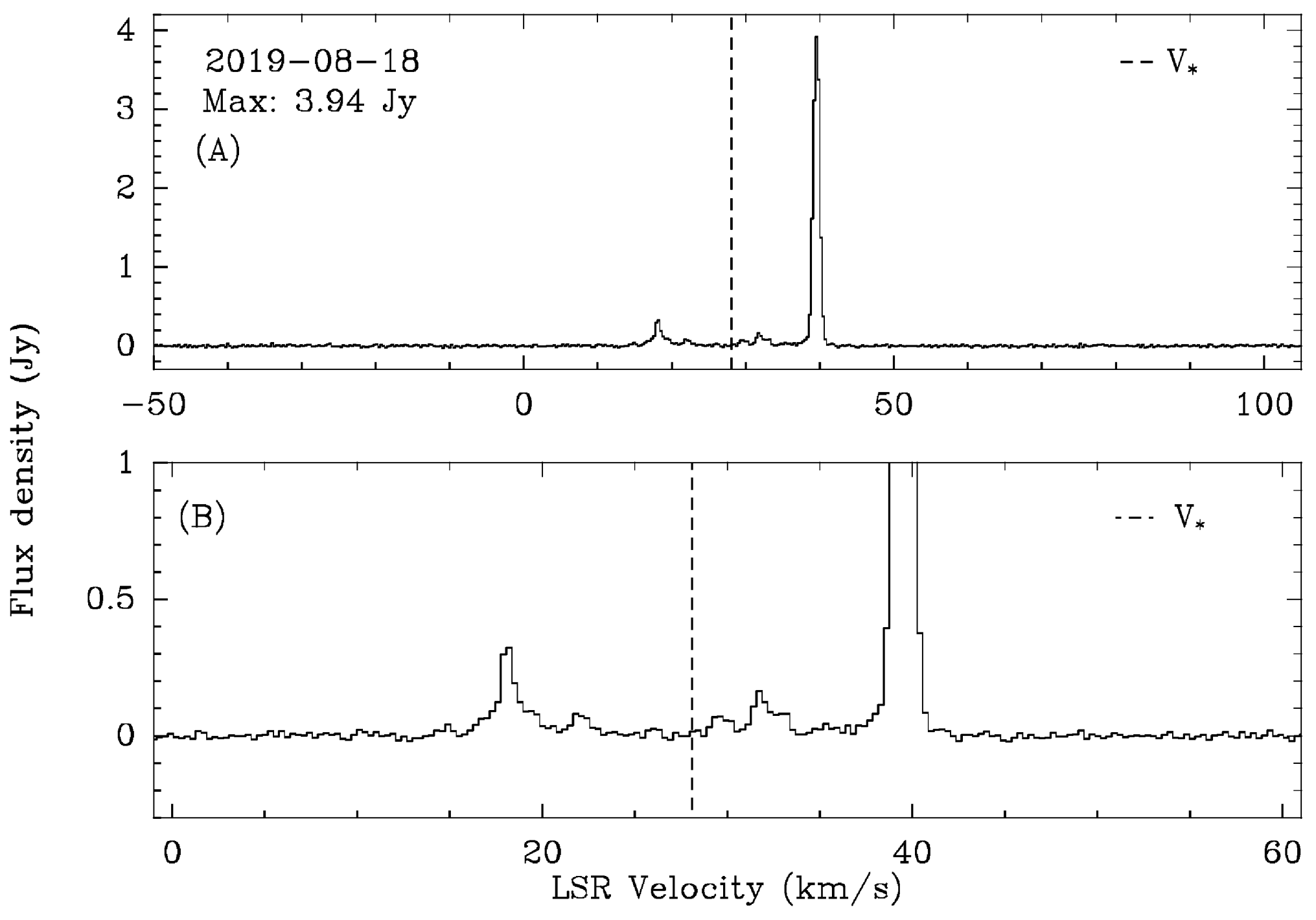

Fig. 2. H_2O maser emission spectrum toward OH16.3. (A) shows the full velocity coverage of the spectra, similar to that of WFs. Zoom in (B) to better show the faint emission components.

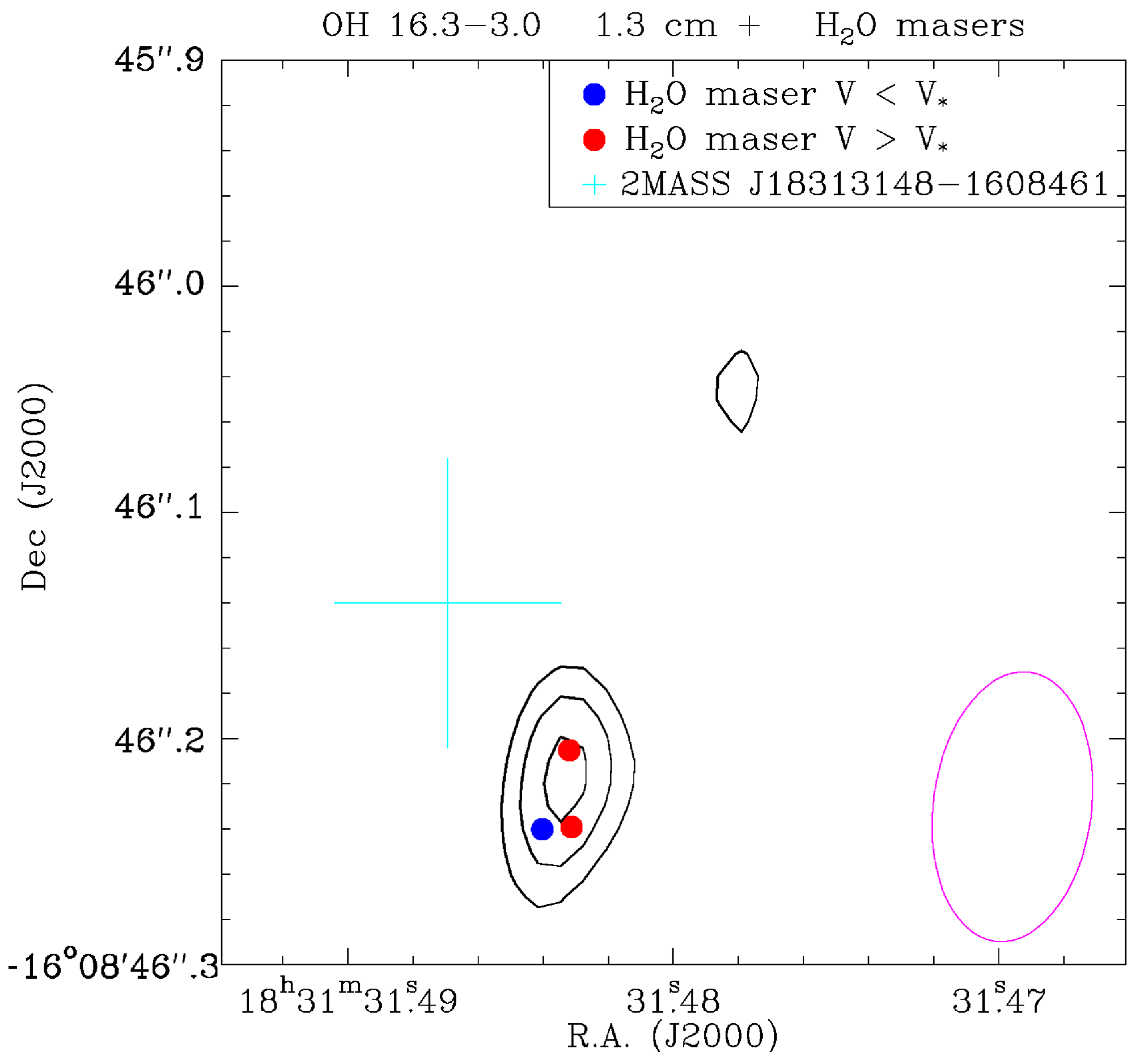

Fig. 3. Contour map of the radio continuum emission of OH16.3 at 1.3 cm from VLA. The contours are 3,4,5 times 1.3x10^{-5} Jy beam^{-1}. The positions of the H_2O maser components are indicated by red and blue dots according to their velocities. The relative positional accuracy of the H_2O masers is < 3.5 mas. The size of the cross of the 2MASS position indicates a 1σ position error. The magenta ellipse is the synthesized beam of the radio continuum.

We also detect OH maser emission at 1612 MHz (Fig. 4). This emission can be associated with an aspherical circumstellar envelope due to: 1) Its peculiar OH maser spectrum, 2) the spatial distribution of its blue- and red-shifted masers is overlapped in the plane of the sky (not shown here), and 3) the deviations of an arc-shaped structure expected for a spherical AGB shell (Fig. 1) in its V-R diagram (Fig. 5). The narrower velocity spread in the H_2O maser emission (24 km s^{-1}), compared with the OH emission (33 km s^{-1}) does not allow us to confirm OH16.3 is a bona fide WF. However, it may be a peculiar AGB or post-AGB star with a non-spherical wind. We should not discard this object as a WF, despite the smaller velocity spread in the H_2O maser spectrum than in OH. It could be a projection effect, if jets are moving close to the plane of the sky, or they might also represent a different kind of source (e.g., with less massive progenitors, or being relatively younger sources [8]).

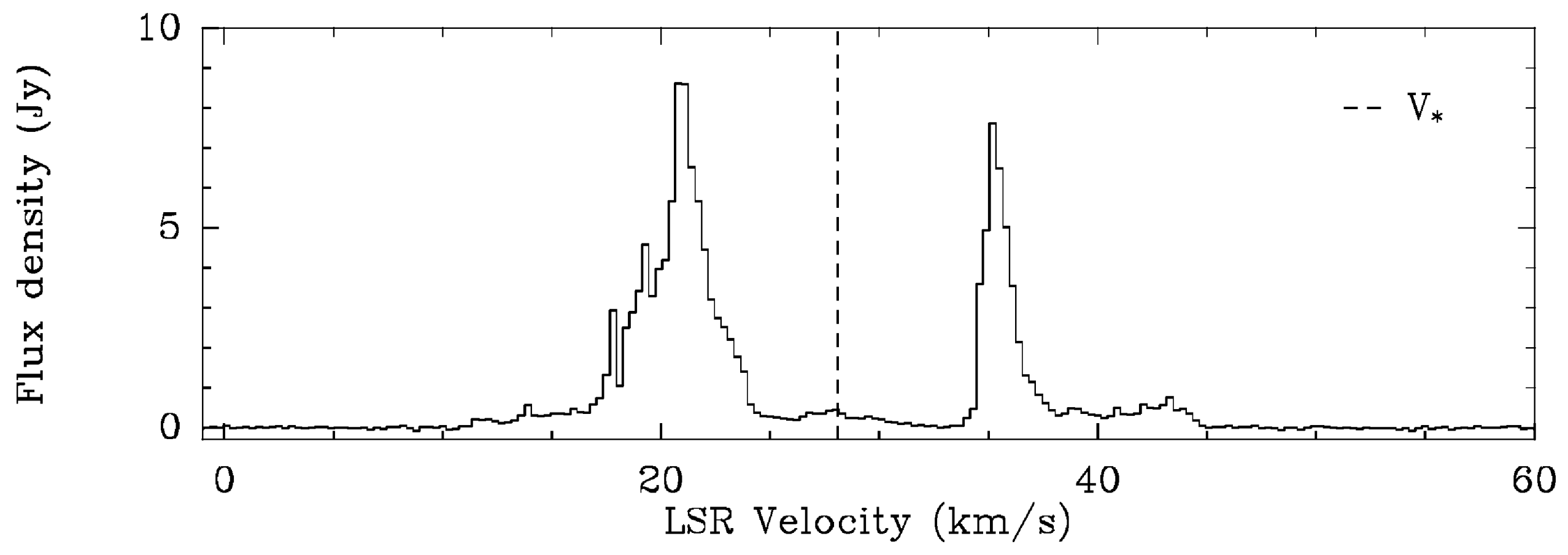

Fig. 4. OH maser emission spectrum toward OH16.3. It shows a double-peak profile with prominent wings.

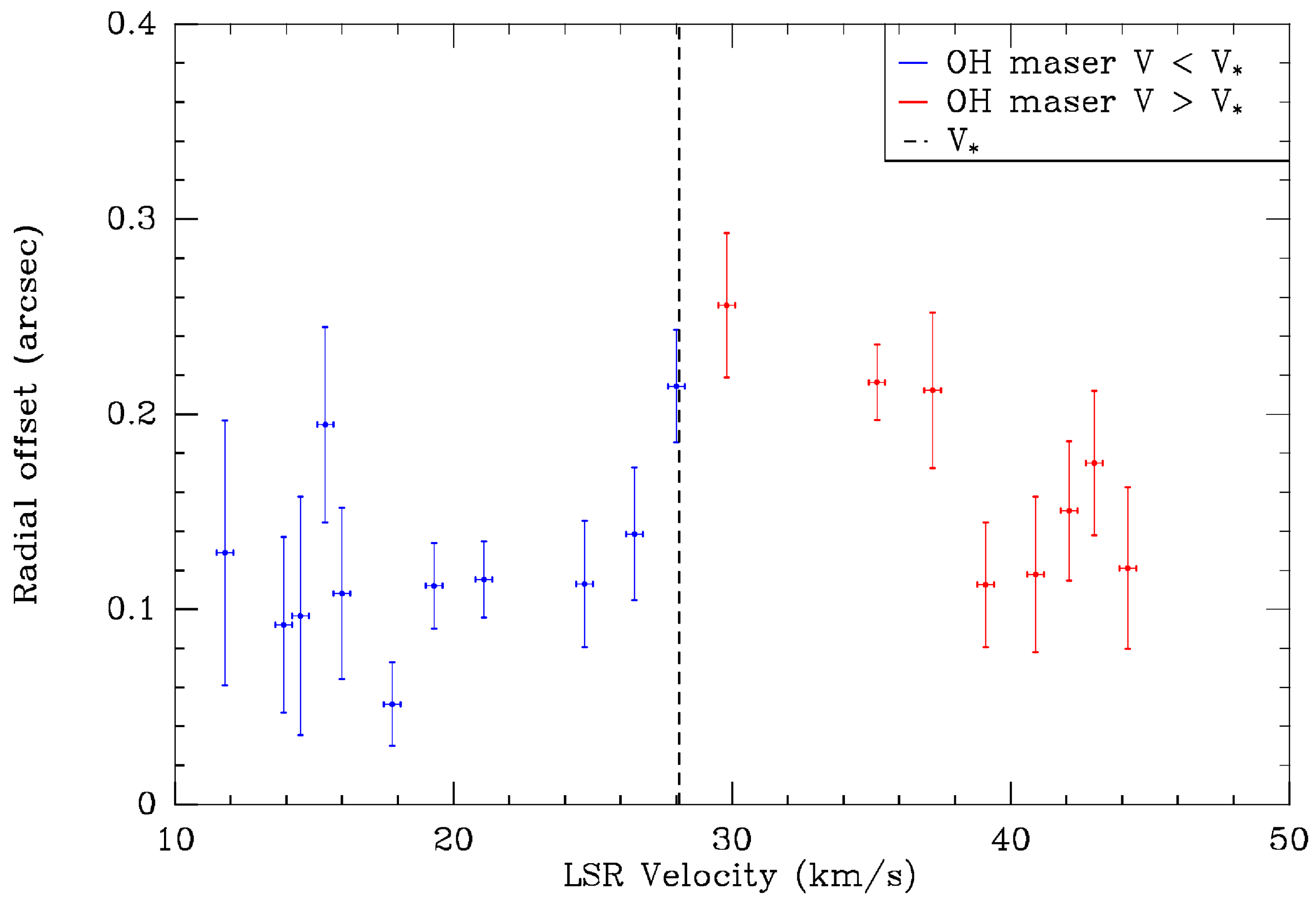

Fig. 5. Velocity-radius diagram for OH16.3. It shows the radial offsets of the maser components from the stellar position, plotted against the observed velocity (with respect to the local standard of rest). Since the stellar position is unknown, we considered the weighted emission centroid of the OH maser positions as the zero radial offset.

We did not detect H_2O maser emission in I19356 with a 3σ limit of 17.7 mJy, despite of an earlier detection with single-dish observations, flux densities ~0.2 Jy and rms of 10 mJy [2].