Cosmic Masers: Proper Motion toward the Next-Generation Large Projects
Proceedings IAU Symposium No. 380, 2024
T. Hirota, H. Imai, K. Menten, & Y. Pihlström, eds.
doi:10.1017/S1743921323003137

Annual parallax measurement of extreme OH/IR candidate star OH39.7+1.5

Ryosuke Watanabe

Graduate School of Science and Engineering, Kagoshima University. email: k7299015@kadai.jp

Abstract. OH/IR stars are low- to intermediate-mass stars (about 0.5-8 solar masses) in the AGB phase, and are considered to be in the process of evolving from Mira variables to planetary nebulae. We aim to understand the evolutionary stages of these AGB stars by approaching them from astrometric VLBI observations with VERA. In 2017, we have started VLBI observations of several OH/IR stars including OH39.7+1.5 presented in this poster. We observed the H_2O maser of OH39.7+1.5 and obtained an annual parallax of 0.55 ± 0.03 mas (distance D = 1.81 ± 0.12 kpc). Using this annual parallax, we revealed distribution (about 35 au square), internal motions, and expansion velocities (average about 15.4 ± 5.1 km s^{-1}) of the maser spots. We compared expansion velocity of H_2O maser with that of OH maser and found to be consistent across the error range. This suggests that the radial velocity of H_2O gas around OH39.7+1.5 has reached a terminal velocity. OH39.7+1.5 has not data on annual parallax or proper motion in Gaia DR3, and this is the first time that annual parallax has been measured.

Keywords. masers, astrometry, parallaxes, star:AGB and post-AGB

1. Introduction

Stars with initial mass of low- to intermediate-mass experience an asymptotic giant branch (AGB) phase at the end of their evolution. OH/IR stars are considered to be in the AGB phase, the stage of evolution from Mira variables to planetary nebulae (Herwig 2005). This phase is the late AGB phase. The late AGB phase is a very short time in their lives, although the details of the stellar evolution are unclear. We intend to systematically study the evolutionary process and the circumstellar structure by estimating the distance from the annual parallaxes obtained from astrometric VLBI using the VERA and investigate the distribution and motion of the circumstellar maser.

2. Observations

2.1. *VLBI Observations*

We observed H_2O maser at 22GHz of OH39.7+1.5 using the VLBI Exploration of Radio Astrometry (VERA) at 22 epochs from October 3, 2019 to May 22, 2022 with an interval of about one month. The VERA is a VLBI array which consists of four 20 m aperture radio telescopes located at Mizusawa, Iriki, Ogasawara, and Ishigaki-jima. Each antenna of VERA has a dual beam system, which is excellent for measuring the annual parallax of dusty AGB stars like OH/IR stars. The VERA cancel out the phase fluctuation caused by atmosphere by simultaneously observing a target and position reference source (J1856+0610) with dual-beam system. The bandwidth of OH39.7+1.5 is 1 IF (16 MHz), divided into 512 channels, with a frequency resolution of 31.25 kHz. This corresponds to a velocity resolution of 0.42 km s^{-1} at 22 GHz. The bandwidth of J1856+0610 is 15 IF (240 MHz), each 16 MHz IF divided into 32 channels.

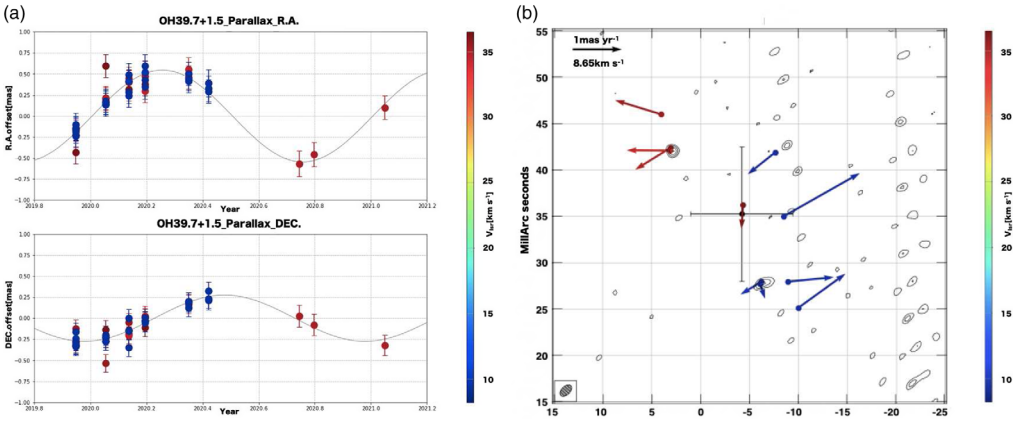

Figure 1. (a) Annual parallax of OH39.7+1.5 and (b) H_2O maser distribution and internal motion.

2.2. *Target source*

OH39.7+1.5 (also named as RAFGL 2290,V1366 Aql, and IRAS 18560+0638) is an OH/IR star with a spectral type of M II. It has emissions of SiO, H_2O, and OH masers. From previous studies, the pulsation period is known to be 1360 days from monitored observations of the OH maser, and OH 39.7+1.5 is a candidate for an Extreme-OH/IR star. OH39.7+1.5 has no data on annual parallax or proper motion in Gaia DR3.

3. Results and Discussion

3.1. *Parallax of OH39.7+1.5*

We determine an annual parallax of OH39.7+1.5 using positions of maser spots detected in the phase-referencing analysis (Figure 1(a)). From 9 out of 16 VLBI observations, we found 10 H_2O maser spots in 6 velocity channels. As a detection threshold, we adopted a signal to noise ratio of 7. We derived a parallax of 0.55 ± 0.03 mas. This corresponds to a distance of 1.81 ± 0.12 kpc. OH39.7+1.5 has no data on annual parallax or proper motion in Gaia DR3, and this is the first time that annual parallax has been measured.

3.2. *H_2O maser distribution and internal motion*

In Figure 1(b), we presented distribution of maser features integrated over 91 velocity channels (velocity width 38.2 km s^{-1}) and internal motion of H_2O maser spots. Maser spots detected three or more times were used to estimate internal motion. The map covers an area of 40 mas × 40 mas (about 72 au × 72 au). The maser spots are distributed from northeast to southwest over an area of about 35 au. The average expansion velocity is 15.4 ± 5.1 km s^{-1}, which is indicative of the expansion velocity of the H_2O maser of a typical AGB star (Höfner & Olofsson 2018). In a previous study, the expansion velocity of the OH maser of OH 39.7+1.5 was obtained to be around 16.5 km s^{-1} (Baud & Habing 1983). Since the H_2O maser is accelerated to the same degree as the OH maser, it is considered to be approaching the terminal velocity. The maser distributions of the two OH/IR stars obtained by our group show the most blue-shifted component consistent with the estimated position of the central star. The most blue-shifted component of OH39.7+1.5 is detected about 8 mas southwest of the central star. This distribution is different from that of previous studies.

https://doi.org/10.1017/S1743921323003137 Published online by Cambridge University Press

References

Baud, B. & Habing, H. J. 1983, *A&A*, 127, 73
Herwig, F. 2005, *ARAA*, 43, 435
Höfner, S. & Olofsson, H. 2018, *A&AR*, 26, 1

https://doi.org/10.1017/S1743921323003137 Published online by Cambridge University Press

Photographs taken during the social events. Top: Afternoon tea during the excursion, taken by Ka-Yiu Shum. Bottom: A local vinegar factory visited during the excursion, taken by Tomoya Hirota.

https://doi.org/10.1017/S1743921323003137 Published online by Cambridge University Press

Photographs taken during the social events. Top: Observatory of the Sakura-jima volcano, taken by Ka-Yiu Shum. Bottom: Dancing during the banquet, taken by Ryosuke Watanabe.

https://doi.org/10.1017/S1743921323003137 Published online by Cambridge University Press