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Discovery of SiO masers in the "Water Fountain" source, IRAS 16552–3050

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Abstract. We report new detections of SiO $v = 1$ and $v = 2$ $J = 1 \to 0$ masers in the "water fountain" source IRAS 16552-3050, which was observed with the Nobeyama 45 m telescope from March 2021 to April 2023. Water fountains are evolved stars whose H_2O maser spectra trace high-velocity outflows of >100 km s^{-1}. This is the second known case of SiO masers in a water fountain, after their prototypical source, W 43A. The line-of-sight velocity of the SiO masers are blue-shifted by $\sim$25 km s^{-1} from the systemic velocity. This velocity offset imply that the SiO masers are associated with nozzle structure formed by a jet penetrating the circumstellar envelope, and that new gas blobs of the jet erupted recently. Thus, the SiO masers imply this star to be in a new evolutionary stage.

Keywords. masers, stars: AGB and post-AGB, stars: mass loss, stars: winds, outfows

1. Introduction

"Water fountain" (WF) sources are dying stars, in the asymptotic giant branch (AGB) or post-AGB phases, that show bipolar jets traced by H_2O maser emission. To date, 15 WFs have been confirmed (e.g. Gómez *et al.* 2017). Interestingly, the WFs exhibit a wide variety in the spatio-kinematics of their H_2O masers as summarized in Imai *et al.* (2020). Recent molecular line observations of the WFs have suggested that the central stellar system is probably a binary forming a common envelope (e.g., Khouri *et al.* 2021).

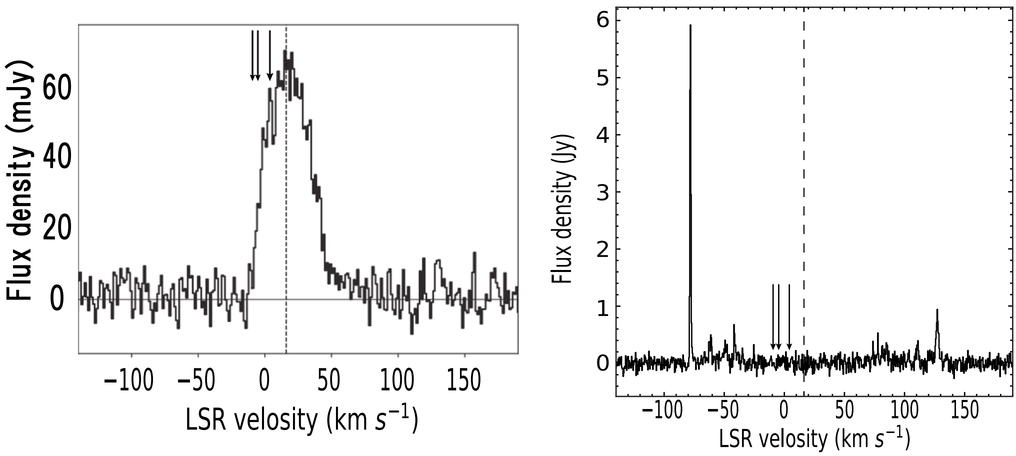

Figure 1. *Left*: Spectrum of CO ($J = 1 \rightarrow 0$) emission observed with ALMA. A vertical dashed line indicates the systemic velocity, V_{sys} = 16 km/s. Vertical arrows indicate the velocities of the SiO masers around $V_{LSR} \sim -9$, -5, 4. The SiO masers are blue-shifted by ∼25 km/s from the V_{sys}. *Right*: Spectrum of the H_2O maser observed with Nobeyama 45m radio telescope. The vertical dashed line and vertical arrows are the same as those in left panel.

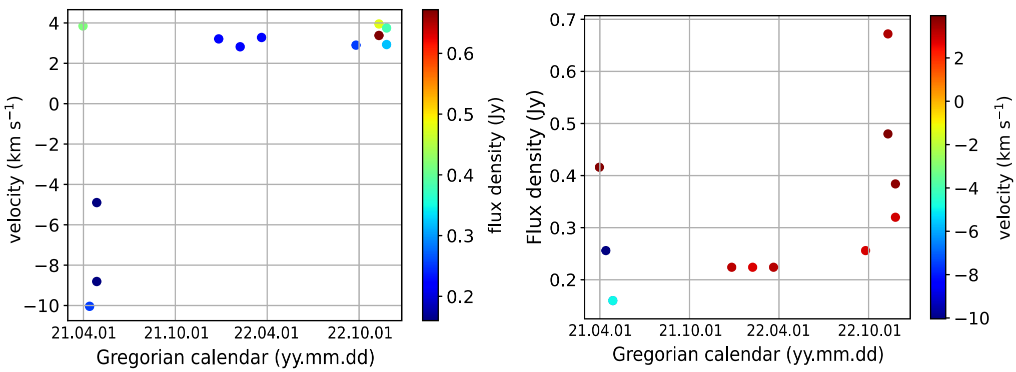

Figure 2. Time variation in the spectral peaks of SiO v = 2 masers toward IRAS 16552-3050. The left and right panels show the variation in LSR velocity and flux density for the individual spectral peaks, respective. Periodicity is not confirmed for either LSR velocity or flux density. (Our poster showed that new redshift components was also detected, but it was a fake due to a mistake of analysis.)

However, the evolutionary status of WFs in the context of stellar evolution is still mostly unknown due to the limited information on the vicinities of their central systems. To date, the presence of SiO masers has been confirmed in only one WF, W 43A (Nakashima & Deguchi 2003). Imai *et al.* (2005) mapped the W 43A SiO $v = 1$ $J = 1 \rightarrow 0$ masers, exhibiting a biconical outflow with a wide full opening angle (∼40°). However, the W 43A SiO masers have vanished.

2. SiO masers in IRAS 16552–3050

We detected the SiO $v = 1$ and $v = 2$ masers in IRAS 16552-3050 (hereafter abbreviated as I16552) on 2021 March. The first SiO maser observation toward IRAS I16552 had been conducted on 2011 using KVN, but the SiO maser had not been detected (Yoon *et al.* 2014). Although our intensive monitoring observations have been conducted since 2018

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December using the Nobeyama 45m radio telescope, SiO maser has never been detected. Therefore, the SiO masers of I16552 were detected for the first time.

The SiO masers are blueshifted by $\sim$13–25 km s^{-1} from the systemic velocity, which is determined from the spectrum of the CO $J = 2 \rightarrow 1$ emission obtained with ALMA. This velocity offset is comparable to those in W 43A ($\sim$20 km s^{-1}, Imai *et al.* 2005). In W 43A, the SiO masers exhibited biconical expansion at a velocity less than that of H_2O masers. This supports a model in which the SiO masers were associated with the jet's nozzles formed in entrained material dragged by the fast jet (Tafoya *et al.* 2020). In fact, the velocities of the SiO masers corresponded to the spectral edge of the CO emission. The SiO masers in I16552 may resemble in the case of W 43A, but it should be confirmed in future observations by finding the red-shifted counterpart SiO masers and by spatially locating these masers.

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