
The Water Fountain in the Pre-Planetary Nebula IRAS19190+1102

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Summary. We present 22.2 GHz water maser observations of the candidate “water fountain” pre-planetary nebula IRAS19190+1102, made using the Green Bank Telescope and the Very Long Baseline Array. The masers are spread over ~ 125 km s^{-1} , and particularly striking are two groups of high-velocity blue- and red-shifted masers. These high-velocity masers are distributed in two opposing arcs implying a bipolar structure, similar to what is observed in other water fountain objects. At an assumed kinematic distance of 8 kpc the arcs are about 320 AU in width, and are separated by approximately 4300 AU. The outflow has a three-dimensional velocity of 117 km s^{-1} and a dynamical age of ~ 100 yr.

1 Introduction

The transition phase of an asymptotic giant branch (AGB) star into a planetary nebula (PN) is a short stellar evolutionary stage (≤ 1000 yrs). During this stage, a spherically symmetric morphology often changes into an aspherical one, by mechanisms that still are poorly understood. Recent observations and modeling support a mechanism involving fast jets, or collimated outflows, that originate around the time of the stellar transition off the AGB [10].

Pre-planetary nebulae (PPNe) comprise a class of objects believed to be in this specific transitory phase. The “water fountain” subclass of PPNe is an interesting group to study because they exhibit red and blueshifted H_2O maser features with radial velocity separations ≥ 70 km s^{-1} [7]. To date, there have been four confirmed water fountain PPNe: IRAS19134+2131 [3], IRAS16342–3814 [9, 11], W 43A [2], and OH 12.8-0.9 [1]. In IRAS19134+2131 [6] and IRAS16342–3814 [9] the axes of separation between the red and blueshifted groups of masers are aligned with the major axes of the optical nebulae. This suggests that the outflows play an important

role in shaping bipolar lobe structures. In W43A, the distribution and kinematics of H₂O masers agrees with a precessing jet model [4], and polarization observations imply that magnetic fields are involved in the collimation of the jet [12]. The outflows in water fountain PPNe appear to have dynamic ages ranging from 50-150 yrs [1], consistent with a fast change of the circumstellar environment.

In a survey of OH and H₂O masers in a sample of IRAS objects with cool infrared colors [6], 1612 and 1667 MHz OH maser emission, as well as 22.2 GHz H₂O emission were detected in the source IRAS19190+1102 (hereafter IRAS19190). The H₂O masers were distributed in two distinct velocity ranges, resembling the velocity distribution found in water fountain PPNe. Here we report on new observations of the H₂O masers, confirming that IRAS19190 is the fifth member of the water fountain PPN class.

2 GBT Observations

IRAS19190 was observed in the $6_{16} \rightarrow 5_{23}$ transition of water (rest frequency 22235.08 MHz), 2003 April 29 using the Green Bank Telescope (GBT). The spectrum, shown in Figure 1, shows two bright groups of emission, centered at $V_{\text{LSR}} = 0$ and 59 km s^{-1} and symmetric about the systemic velocity $V_{\text{LSR}} = 29 \text{ km s}^{-1}$, determined from a 1667 MHz emission spectrum [6]. Comparing our spectrum with that obtained by Likkell et. al (1992) [6], we find these groups of emission have remained stable in velocity extent over 15 years, although individual peaks have changed drastically. A comparatively weak emission feature not previously detected is apparent at $V_{\text{LSR}} = 113 \text{ km s}^{-1}$ (Fig. 1).

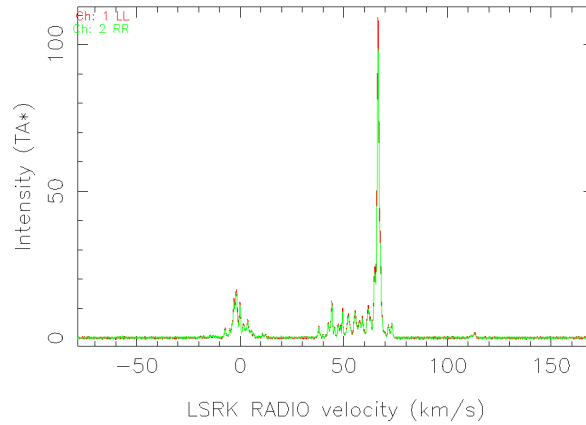


Fig. 1. The GBT H₂O 22.2 GHz maser spectrum of IRAS19190 from the May 29, 2003 epoch. The GBT K-band receiver gain is $\sim 1.6 \text{ K Jy}^{-1}$.

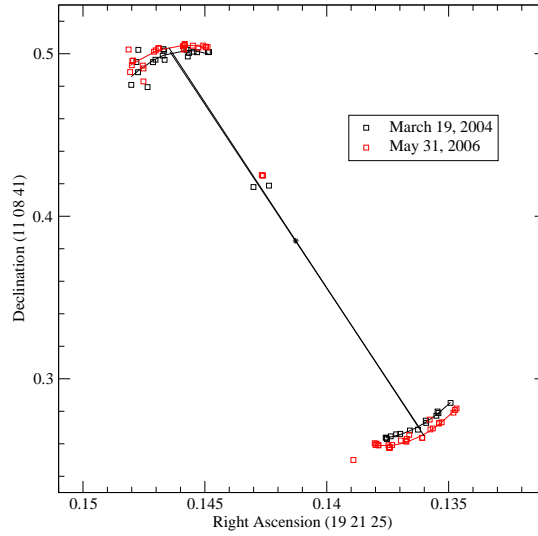


Fig. 2. The distribution of the H₂O maser emission from IRAS19190 from the March 19, 2004 and May 31, 2006 epochs.

3 VLBA Observations

The H₂O masers in IRAS19190 have also been observed during two epochs using the Very Long Baseline Array (VLBA), for a total of 6 hours per epoch on 2004 March 19 and May 31. We have registered the data from the two epochs by co-locating their geometric centers. Figure 2 shows the distribution of the maser features for both epochs. The blue-shifted (NE) and red-shifted (SW) groups of maser features in each epoch are distributed in two arcs. The separation axis between the positional mean of the two regions has a position angle of 33° east of north. The two arcs are ~45 mas in width and are separated by 277 mas and 283 mas in the 2004 and 2006 epochs, respectively. The distribution of each group of maser features is presented in Figures 3 and 4. Emission detected by the VLBA in these arcs spans the velocity ranges [-14, 10] km s⁻¹ and [38, 66] km s⁻¹ in the 2004 epoch and [-20, 11] km s⁻¹ and [40, 78] km s⁻¹ in the 2006 epoch. The flux densities of maser features in similar regions of emission changes significantly between epochs.

A third group of emission lies approximately 33 mas NE along the separation axis from the center of the system. The radial velocity of maser emission in this region shifts significantly from $V_{\text{LSR}} \simeq -10$ km s⁻¹ to -43 km s⁻¹ between the two epochs. Compared to the steady radial velocities exhibited by masers seen in the arcs, this drastic velocity change is puzzling, and for which we do not yet have a good explanation.

Assuming a uniform flow, each arcs of maser emission expands at 1.35 mas yr⁻¹ from the center, along the axis of separation, giving an estimated dynamical age of the flow of ~100 yrs. The assumed kinematic distance to IRAS19190 is 8 kpc. Using a radial expansion velocity of 30 km s⁻¹, the outflow is inclined 30° to the plane of the sky and has a one-sided 3D expansion velocity of 58.5 km s⁻¹. The 3D physical

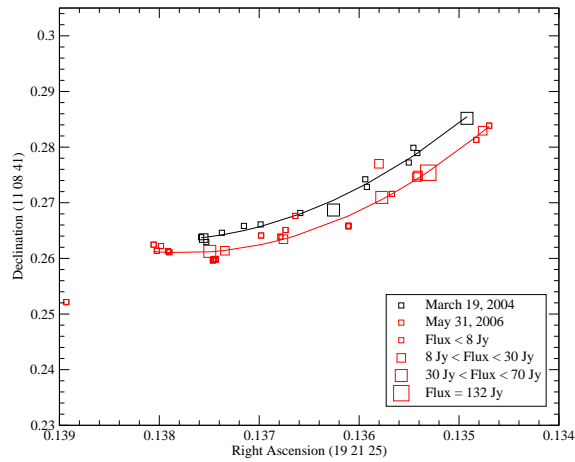


Fig. 3. The distribution and flux density map of the redshifted (SW) group of H₂O maser emission from IRAS19190 from the March 19, 2004 and May 31, 2006 epochs.

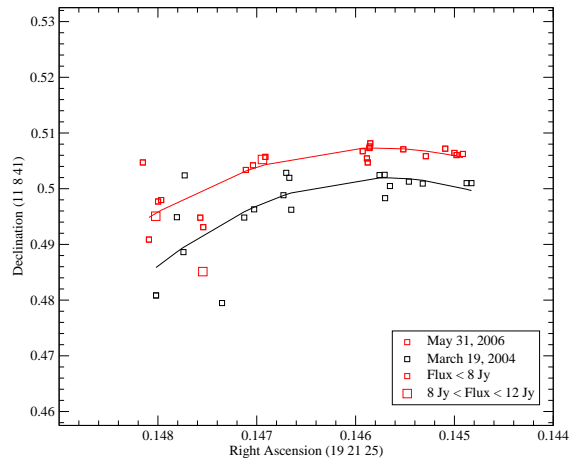


Fig. 4. The distribution and flux density map of the blueshifted (NE) group of H₂O maser emission from IRAS19190 from the March 19, 2004 and May 31, 2006 epochs.

separation of the arcs of emission is then about 4300 AU; the 45 mas angular width is ~ 340 AU, and the opening angle of the jet-like structure is 18° .

4 Summary and Future Work

These GBT and VLBA observations confirm that IRAS19190 indeed is the fifth member of the water fountain class of PPNe. The maser emission is distributed in two inward-facing arcs and are separated into a bipolar structure similar to what

is observed in other water fountain PPNe. At the assumed distance of 8 kpc, the arcs are separated by a 3D distance of about 4300 AU and the 3D outflow velocity of each arc is 58.5 km s^{-1} , parameters that are comparable to other water fountain PPNe.

Ongoing astrometric VLBA observations of the OH and H₂O maser emission in IRAS19190 should provide an accurate distance determined by trigonometric parallax. The observations will facilitate the study of the relative locations and kinematics of the maser emission. Further, we hope to find more detailed information of the third group of water maser emission observed near the center of the system of IRAS19190, and the possible role of these masers in the kinematics of the collimated fast outflow.

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