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A molecular jet in the pre-planetary nebula IRAS 19134+2131

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Abstract. Using the VLBA, we have observed water maser emission in the pre-planetary nebula candidate, IRAS 19134+2131 (I1913), in which the water maser spectrum has two groups of emission features separated in radial velocity by $\sim$100 km s^{-1}. The morphology and 3-D kinematics indicate the existence of a fast collimated flow with a dynamical age of only $\sim$40 years. Such a "water fountain" source is a signature of the recent operation a stellar jet that may be responsible for the final shape of the planetary nebula into which I1913 is expected to evolve. We have also estimated the distance to I1913 on the basis of an annual parallax and the kinematics of IRAS 19134+2131 in our Galaxy. I1913 may be a component in the "thick disk" or the Galactic "warp", whose kinematics are different from those of the Galactic "thin" disk.

Keywords. masers, stars:AGB and post-AGB; kinematics; individual(IRAS 19134+2131)

1. Introduction

"Water fountain sources" are H_2O masers associated with AGB or post-AGB stars, but exhibiting much higher expansion velocities than those observed in classical OH/IR stars. They have been revealed to be highly-collimated (precessing) bipolar jets of molecular gas launched prior to forming planetary nebulae (Imai *et al.* 2002). So far there are only four water fountains investigated with VLBI observations: IRAS 16342−3814 (e.g. Morris, Sahai & Claussen 2003), OH12.8−0.9 (Boboltz & Marvel 2005), W43A (e.g. Imai *et al.* 2002), and IRAS 19134+2131 (I1913) (Imai *et al.* 2004). Investigating these sources in more detail should provide us important clues for elucidating the evolution/devolution of the water fountains and the mechanism for shaping planetary nebulae. Here we report VLBA observations of the I1913 at 6 epochs during 2003 January–2004 April. All observations have applied the phase-referencing VLBI technique, in which all maser feature positions are determined with respect to the extragalactic reference source J1925+2106 (see figure 1).

2. Results and discussion

In I1913, a clear bipolar flow with high spatial (a major-to-minor axis ratio of 9.7) and kinematical (a major-to-perpendicular velocity dispersion ratio of 4.8) collimation was recognized (see figure 2). The dynamical age of the flow is estimated to be $\sim$40 yrs, which is roughly equal to those of other water fountain sources (c.f., $\sim$50 yrs for W43A, Imai *et al.* 2005) and may give a typical lifetime of the water fountains. The maser spots in the eastern cluster are misaligned from the apparent outflow axis, indicating

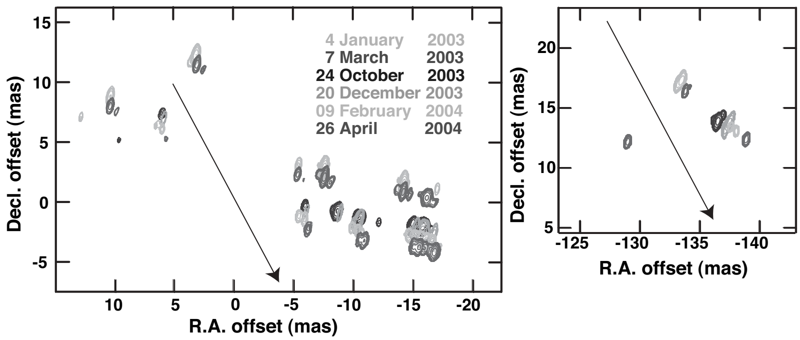

Figure 1. Velocity-integrated images of the H_2O masers in IRAS 19134+2131. An arrow indicates a mean secular source motion per four years.

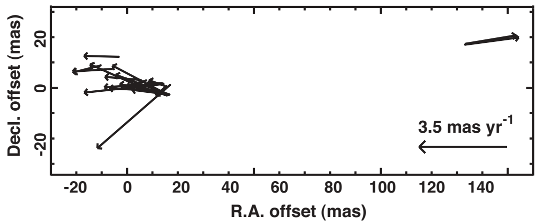

Figure 2. Relative proper motions of the H_2O masers in IRAS 19134+2131, with a systemic secular motion subtracted.

the possible presence of precessional motions in the outflow in I1913; however, further study is needed to confirm this. Note that some water fountains have optical nebulosity (IRAS 16342−3814 and I1913) while others do not (W43A and OH12.8−0.9), suggesting that the presence of water fountains may help in the identification of new pre-planetary nebulae, which may be optically invisible due to heavy circumstellar extinction.

In addition, the phase-referencing VLBI technique provides us with information on the absolute kinematics of the H_2O maser source, giving an annual-parallax distance $D \sim 8.0$ kpc and a mean secular motion. The derived location and the 3D velocity components of I1913 are $(R, \theta, z) \simeq$(7.6 kpc, 59°.4, 650 pc) and $(V_R, V_\theta, V_z) \simeq$(−56, 149, 49) [km s^{-1}], respectively. Thus I1913 is located at a large height from the Galactic plane and its kinematics are very different than expected simply from the Galactic circular rotation. This is puzzling because progenitors of bipolar planetary nebulae are expected to be higher-mass stars and tend to be located close to the Galactic plane.

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