A Giant Step: from Milli- to Micro-arcsecond Astrometry
Proceedings IAU Symposium No. 248, 2007
W. J. Jin, I. Platais & M. A. C. Perryman, eds.

doi:10.1017/S1743921308019054

Distance and kinematics of IRAS 19134+2131 revealed by H_2O maser observations

H. Imai[1], R. Sahai[2] and M. Morris[3]

[1]Department of Physics, Kagoshima University, 1-21-35 Korimoto, Kagoshima 890-0065, Japan, email: hiroimai@sci.kagoshima-u.ac.jp

[2] Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109,USA, email: raghvendra.sahai@jpl.nasa.gov

[3] Department of Physics and Astronomy, University of California, Los Angeles, CA 90095−1562, USA, email: morris@astro.ucla.edu

Abstract. Using the VLBA, we have observed H_2O maser emission in the pre-planetary nebula, IRAS 19134+2131 (I1913), in which the H_2O maser spectrum has two groups of emission features separated in radial velocity by ∼100 km s^{-1}. The morphology and 3-D kinematics indicate the existence of a fast collimated flow with a dynamical age of only ∼40 years. Such a "water fountain" source is a signature of the recent operation of 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 (∼8 kpc) 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 is different from that of the Galactic "thin" disk. These results are reported in Imai, Sahai & Morris (2007).

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

"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 the planetary nebulae. So far there are 11 sources identified as water fountain sources. Investigating these sources in more detail using VLBI technique should provide us important clues for elucidating the evolution/devolution of the water fountains and the mechanism of shaping planetary nebulae. Here we report results of VLBA observations of the IRAS 19134+2131 (I1913) H_2O masers 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).

In I1913, a clear bipolar flow with high spatial and kinematical collimation was recognized (see figure 1). The dynamical age of the flow is estimated to be ∼40 yrs, which is roughly equal to those of other water fountain sources and may give a typical lifetime of water fountains. Note that some water fountains have optical nebulosity while others do not, suggesting that the presence of water fountains may help in the identification of new pre-planetary nebulae, which may be optically invisible due to the heavy circumstellar extinction.

The phase-referencing VLBI technique provides us information on the absolute kinematics of the H_2O maser source (see figure 2), giving the annual-parallax distance $D = 8.0^{+0.9}_{-0.7}$ kpc and the mean proper motion. The derived location and the 3D velocity

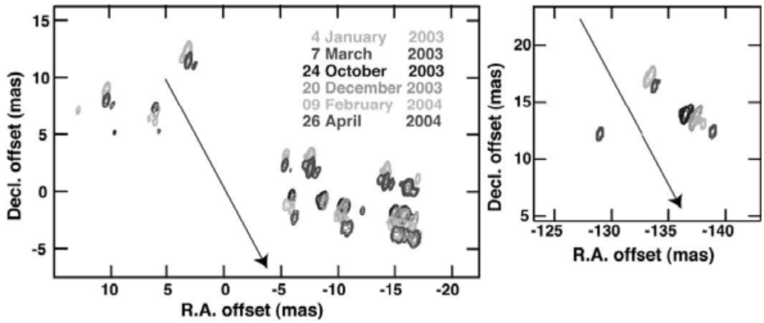

Figure 1. Velocity-integrated images of the H_2O masers in IRAS 19134+2131. An arrow indicates the mean motion in four years.

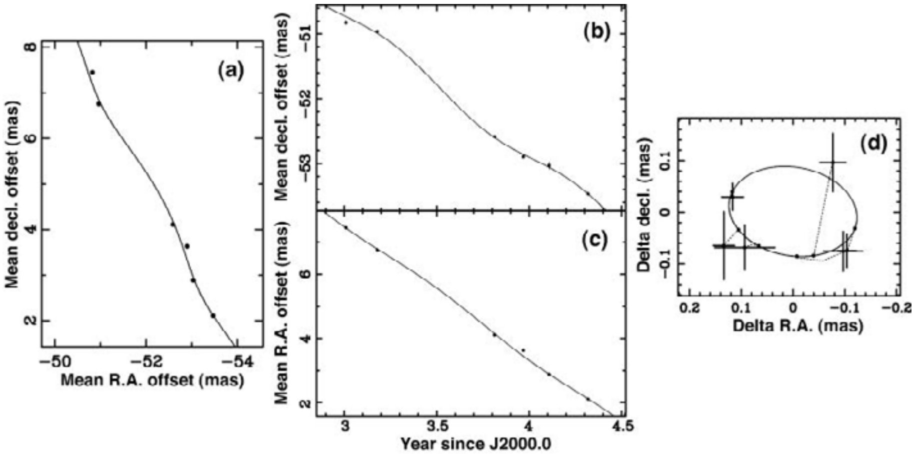

Figure 2. Mean position of the three maser features at all of the observation epochs. (*a*) Mean RA and Dec offsets on the sky with respect to the phase-tracking center. (*b*) and (*c*) Mean RA and Dec offsets against time. (*d*) Relative mean offsets with a position offset and a mean proper motion subtracted. Ellipse indicates the modeled annual-parallax motion. The mean maser position goes clockwise around the ellipse. Each observed point is connected to a relevant point on the ellipse, corresponding to the observation time, with a dotted line.

components of I1913 are $(R, \theta, z) \simeq$(7.4 kpc, 62°.4, 650 pc) and $(V_R, V_\theta, V_z) \simeq$(3, 125, 8) [km s^{-1}], respectively. Thus I1913 is located at a large height from the Galactic plane and its kinematics is very different from that expected simply from the Galactic circular rotation ($V_\theta \simeq 220$ km s^{-1}). From the height above the Galactic plane, z, and the velocity component perpendicular to the Galactic plane, V_z, we estimate a rough upper limit of $\sim$9 $M_\odot$ to the stellar mass of I1913's progenitor.

Acknowledgements

The NRAO's VLBA is a facility of the National Science Foundation of the USA, operated under a cooperative agreement by Associated Universities, Inc. H.I. was supported by the Grant-in-Aid for Scientific Research from Japan Society for Promotion Science (18740109).

References

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