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A COLLIMATED JET OF MOLECULAR GAS FROM THE AGB STAR W 43A

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We present the spatial and velocity distributions of H_2O and OH masers in the OH/IR star W43A. These masers have the same systemic velocity and are, therefore, likely to be associated with the common stellar object. However, the OH masers exhibit clear arc-shaped structures and indicate a spherically-expanding shell, while most of the H_2O masers are extremely collimated spatially and kinematically. The observed angular pattern of the H_2O masers is well fit by a precessing jet model. We infer that an elongated planetary nebula is formed by such a "molecular jet" during the short period (< 1000 years) of the transition through the proto-planetary nebula phase.

H_2O and OH (1612 MHz) masers in W43A have been observed using the VLBA[5] on three occasions: 1994 June 25, 1994 October 10, and 1995 March 17. The obtained angular and velocity resolutions were 0.5 milliarcsecond (mas) and 0.21 km s^{-1} at 22.2 GHz and 9 mas and 0.36 km s^{-1} at 1.6 GHz, respectively. We measured proper motions of 21 H_2O maser features that were detected in two or three epochs (see also Imai et al. 2002). Figure 1 shows the kinematics of the H_2O and OH masers.

Most of the H_2O masers in W43A are concentrated in blue-shifted and red-shifted clusters, both of which are surprisingly spatially collimated with a width of only 20 AU. The two clusters have lengths of 250 to 350 AU and are separated by 1700 AU. The 3-D motions of the masers indicate a collimated, fast jet-like motion with a 3-D velocity of 145 km s^{-1}. In addition, the observed spatial pattern is consistent with a model that considers a precessing jet with a constant velocity of 150 km s^{-1}, an inclination of 36° with respect to the sky plane, a position angle of 63°, and an axis precession with an angular amplitude of 5° and a period of 55 years.

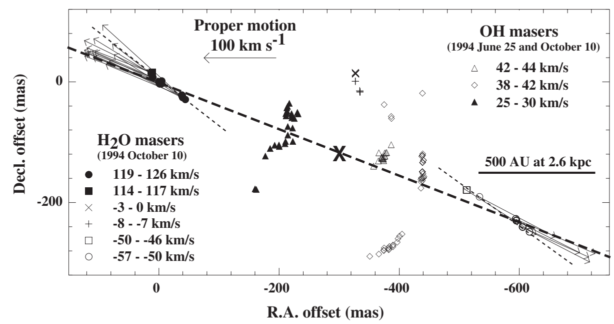

Fig. 1. Kinematics of H_2O and 1612-MHz OH masers in W43A. A dashed line shows the direction of the jet. Two dotted thin lines show the alignments of maser spots in the individual clusters. A cross shows the estimated location of the central object with a systemic radial velocity of $V_{\rm LSR} = 34\,{\rm km\,s^{-1}}$. The position offsets of the OH masers relative to the H_2O masers were estimated by assuming the common central object at the middle point of the red-shifted and blue-shifted OH masers.

In contrast to the H_2O masers, the OH masers in W43A have clear arc-shaped structures that can be fit by a model consisting of a spherically expanding shell with a radius of ~ 500 AU around the star with an expansion velocity of ~ 9 km s^{-1}. Usually, H_2O masers are located closer to evolved stars than OH masers and exhibit morphology and kinematics that are complicated or elongated perpendicular to the directions of the outflows. It is likely that the circumstellar envelope of W43A is destroyed at the nearest point to the star during the final phase of the OH/IR star stage. The H_2O masers will be excited only in the tips of a highly-collimated jet with compact clumps simultaneously ejected from the star. Such a collimated jet originating from an OH/IR star is surprising, but can be explained if W43A contains a binary system; an evolved star and another star generating the OH maser flow and the H_2O maser jet with precession, respectively. The second star is likely to be a unique object that generates such a molecular jet in a short period of evolution prior to a white dwarf.

REFERENCES

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