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THE 3-D KINEMATICS OF WATER MASERS IN THE W 51A REGION

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We report on proper-motion measurements of H_2O masers in the massive-star forming region W51A and analyses of the 3-D kinematics of the masers in three maser clusters of W51A (W51 North, Main, and South). Although we have measured more proper motions of H_2O masers than in previous VLBI observations, we found a systematic motion of masers (an expanding flow) only in W51 North. Fundamentally, the maser kinematics are significantly affected by random motions, implying that several of the young massive stars simultaneously generate outflows and make the maser kinematics around the stars very complicated. We directly estimated the distance to W51 North to be (6.1 ± 1.3) kpc based on the model-fitting analyses of the H_2O maser kinematics.

VLBI observations of the W51A H_2O masers were made at five epochs for a period of 8 months in 1999, using three or four telescopes of the Japanese VLBI Network (see Imai et al. 2002). Because the three maser clusters in W51A are located within a 70″ field, we simultaneously observed them in a single antenna beam. Our observations covered a band width of 16 MHz at 22.2 GHz, corresponding to a Doppler velocity width of 216 km s^{-1}. With the Mitaka FX correlator, we obtained 1024 velocity channels with a velocity spacing of 0.21 km s^{-1} each. The relative position accuracy of maser features ranged over 0.05 to 0.6 mas.

The numbers of measured proper motions were 123, 48, and 10 in W51 North, Main, and South, respectively, which are larger than those of previous observations. Figure 1 presents the 3-D motions of H_2O masers in W51 North, which clearly exhibit an expanding flow. We performed model fitting analyses for the W51N H_2O kinematics assuming a spherically expanding flow. The flow has an expansion velocity of ∼ 70 km s^{-1} and indicates deceleration. The dynamical center of the flow coincides within 0.″1 with a SiO maser source in W51 North. In W51 Main, no systematic motion was found over the whole velocity range (-58 km s^{-1} $\leq V_{\rm LSR} < 158$ km s^{-1}), while a stream motion was previously reported in a limited range of the Doppler velocity (54 km s^{-1} $\leq V_{\rm LSR} <$ 68 km s^{-1}). Multiple driving sources of the outflows are thought to explain the kinematics of W51 Main. In W51 South, an expansion motion like a bipolar flow was marginally visible.

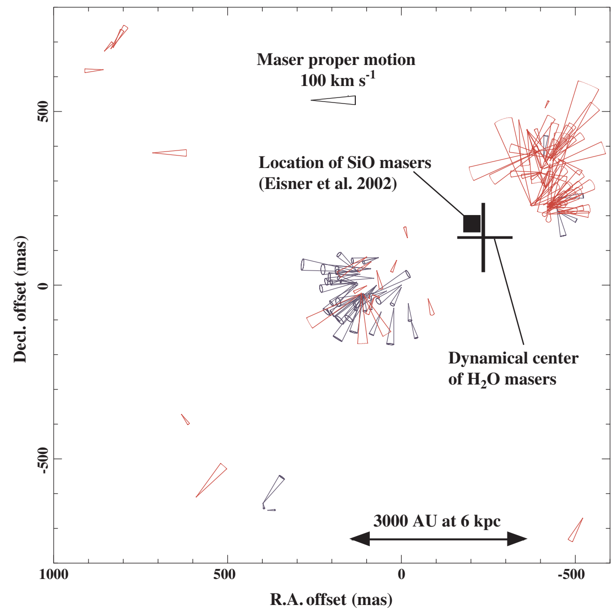

Fig. 1. 3-D motions of H_2O maser features and the location of the dynamical center of the H_2O maser flow in W51 North.

In the above model fitting analyses, we estimated the distance to W51 North to be 6.1 ± 1.3 kpc. If adopting the value previously adopted (∼ 7 kpc), the flow dynamical center has a big (∼ 0.″1) offset from the SiO masers. Our estimation supports the "near" kinematic distance of the W51A region (∼ 5.5 kpc).

REFERENCES

Imai, H., Watanabe, T., Omodaka, T., Nishio, M., Kameya, O., Miyaji, T., & Nakajima, J. 2002, PASJ, 54, 741

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