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Dynamics of jet/outflow driven by high-mass young stellar object revealed by KaVA 22 GHz water maser observations

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Abstract. We have started survey observations of the 22 GHz water maser sources associated with high-mass young stellar objects (HM-YSOs) as a part of the KaVA (KVN and VERA Array) large program (LP). The aim of our LP is to understand dynamical evolution of jets/outflows from HM-YSOs by analyzing 3D velocity structures of water maser features. In the first year (2016-2017), an imaging survey toward 25 HM-YSOs has been conducted and the 22 GHz water masers are detected toward 21 sources. Spatial distributions of maser features for individual sources are mapped. To complement physical properties in the vicinity of HM-YSOs, we have carried out ALMA cycle 3 observations of thermal molecular lines and continuum emissions toward 11 selected samples. Summary of the KaVA first year observations and the initial results from the ALMA toward one of our targets, G25.82-0.17, are reported.

Keywords. ISM: kinematics and dynamics, ISM: jets and outflows

1. Introduction

High mass star formation is far from understanding observationally because of its distant location and high surface density of HM-YSOs. The primary scientific goal of KaVA LP is understanding dynamical evolution of HM-YSOs using measured 3D velocity field and spatial structure of 22 GHz water and 44 GHz Class I methanol masers which could trace different evolutionary stages and different dynamical structures. Especially, water maser at 22 GHz is a good tracer of jet/outflow which is one of the most important signposts of star formation. Driving mechanisms of jet/outflow can be investigated to understand the key role of jet/outflow in massive star formation.

2. Observations and Results

We have carried out VLBI observations at 22 GHz toward 25 sources in total within the first year of project since 2016 with the KaVA. Sources associated with the water masers but with no previous VLBI data at the beginning of the KaVA LP (2014) were selected from the source list (87 HM-YSOs) for the first year observations. The highest angular resolution achieved with the longest base line between Mizusawa and Ishigaki station is 1.2 mas at 22 GHz.

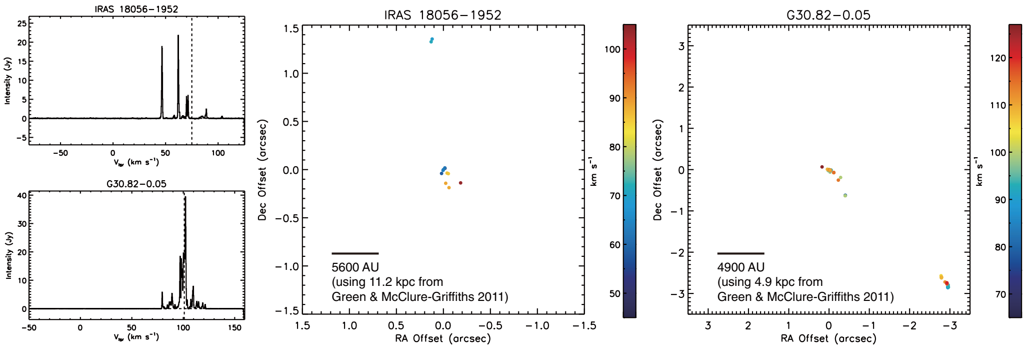

Figure 1. The 22 GHz water maser spectra (*left*) and spatial distribution maps of IRAS 18056-1952 (*center*) and G30.82–0.05 (*right*), respectively. Vertical dashed lines indicate the systemic velocities of each source adopted from the previous thermal molecular line surveys (Shirley *et al.* 2013, Urquhart *et al.* 2011, etc).

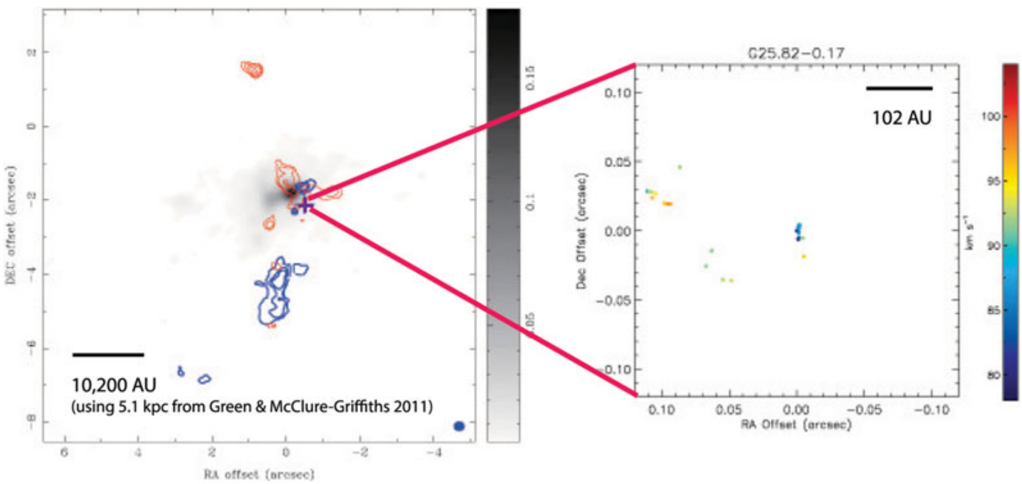

Figure 2. The integrated intensity map of SiO 5–4 overlaid onto dust continuum emission (*left*) and spatial distribution map (*right*) of G25.82–0.17. Bold contours represent the intensities over blueshifted range ($\leqslant$91 km s^{-1}) while normal contours represent the intensities over redshifted range ($\geqslant$93 km s^{-1}). A cross on the left panel denotes the absolute position of water maser emission derived using AIPS task FRMAP.

Water masers were detected toward 21 sources among the observed 25 samples with the detection rate of 84 %. Distributions of water maser features show source-to-source variation; such as elongated structures like G30.82-0.05, arc-like structures as seen in IRAS 18056-1952, etc (Figure 1). Physical properties of the jets/outflows and their driving sources will be investigated by the follow-up studies with ALMA . Preliminary results from ALMA cycle 3 observations (PI:Mikyoung Kim, 2015.1.01571.S) at band 6 (239 GHz) are presented in Figure 2. The SiO 5-4 line and water maser emission are tracing totally different scale of structure (Figure 2). The inner most part near HM-YSOs can be investigated by 3D velocity structure of water maser emission obtained with the KaVA.

References

Green, J. A. & McClure-Griffiths, N. M. 2011, *MNRAS*, 417, 2500
Shirley, Y. L., Ellsworth-Bowers, T. P., Svoboda, B., *et al.* 2013, *ApJS*, 209, 2
Urquhart, J. S., Morgan, L. K., Figura, C. C., *et al.* 2011, *MNRAS*, 418, 1689

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