

## **KaVA Large Proposal for High-Mass Star-Formation Studies with Multiple Masers**

*Tomoya HIROTA, Kee-Tae KIM, KaVA Star Formation Science Working Group*

We have started a systematic observational study of the 22 GHz water masers and 44 GHz class I methanol masers in high-mass star-forming regions as a four-year KaVA (KVN and VERA Array) large program since 2016. The primary aim of our project is to investigate dynamical evolution of high-mass young stellar objects (HM-YSOs) and their circumstellar structures by observing spatial distributions and 3D velocity fields of water and methanol maser features. For statistical studies, we first selected 87 HM-YSOs in various evolutionary phases, based on the catalogues and single-dish surveys of the 22 GHz water masers, 44 GHz class I methanol masers, and 6.7 GHz class II methanol masers. Most of the targets are associated with multiple maser species. From these initial samples, we selected 23 water maser sources and 19 methanol maser sources, for which VLBI data were not available in 2016 and 2017, to check detectability with KaVA and variability of maser features. All the 44 GHz methanol maser sources have been observed for the first time with VLBI. As a result of the first year observations, we selected 16 water maser sources to conduct monitoring observations to measure proper motions in the second year. All of these sources show multiple maser features with various distributions such as linearly elongated structures, compact shell-like structures, and more complex distributions, suggesting variety of outflow structures. In addition, we also selected 3 methanol maser sources to measure the proper motions for the first time with VLBI. Observations have been started since 2018 March and still on-going. By combining follow-up observations with VERA (astrometry), Japanese VLBI Network (6.7 GHz class II methanol masers), ALMA (thermal molecular lines and continuum), and single-dish telescopes (various molecular lines), we will investigate physical properties and 3D dynamical structures of disk, jet, outflow, UCHII, and infalling envelope, and their relationship with the evolutionary phases of HM-YSOs. In this talk, we will present current status of our KaVA large program and initial results from the first year observations and ALMA cycle 3 follow-up observations.