Cosmic Masers - from OH to H_0
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The VLBI mapping survey of the 6.7 GHz methanol masers with the JVN/EAVN

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Abstract. We present VLBI maps of the 6.7 GHz methanol maser emission in 32 sources obtained using the Japanese VLBI Network (JVN) and the East-Asian VLBI Network (EAVN). All of the observed sources provide new VLBI maps, and the spatial morphologies have been classified into five categories similar to the results obtained from European VLBI Network observations (Bartkiewicz *et al.* 2009). The 32 methanol sources are being monitored to measure the relative proper motions of the methanol maser spots.

Keywords. Stars: formation, Masers: methanol, Instrumentation: high angular resolution

1. Introduction

Methanol masers at 6.7 GHz are good tracers for investigating the three dimensional dynamics around high-mass young stellar objects (YSOs). This maser could be associated with an accretion disk around a high-mass YSO because of its ring/elliptical spatial morphology (e.g., Bartkiewicz *et al.* 2009) and rotational/infall proper motions in some sources (Sanna *et al.* 2010a, b; Moscadelli *et al.* 2011; Goddi *et al.* 2011).

We started a VLBI monitoring project of the 6.7 GHz methanol maser in 36 target sources in 2010 using the JVN/EAVN for the investigation of the evolution of accretion disks around high-mass YSOs. This project is still ongoing to measure the relative proper motions of each maser spot around high-mass YSOs. Here, we present each VLBI map for the 32 sources obtained in 2010 Aug. and 2011 Oct. All of these target sources in our VLBI project provided new VLBI maps.

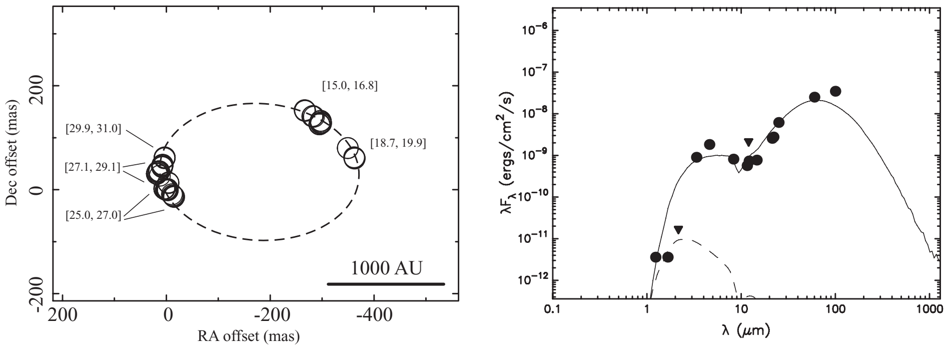

Figure 1. VLBI map of the 6.7 GHz methanol maser spots (left) and SED estimated from the online fitting tool (right; Robitaille *et al.* 2006) in G6.795−0.257. In the left panel, positions of each spot are relative to the reference spot at the origin, and attached numbers indicate a range of radial velocities for each spot. A dashed ellipse shows the model fitted to the maser distribution.

2. Observations and Results

The target 6.7 GHz methanol maser sources were selected from the methanol maser catalog of Pestalozzi *et al.* (2005) and the Methanol Multibeam Survey catalog (Caswell *et al.* 2010; Green *et al.* 2010) using the following criteria: 1) source declination $-40° < \delta < +30°$ (observable with ALMA); 2) total flux densities > 65 Jy in either catalog; 3) no previous VLBI observations. Applying these criteria, 36 sources were selected, and 95% of the target sources (34/36) were located in southern hemisphere (declination $< 0°$).

We observed 22 sources in 2010 Aug. 28-30 and 10 sources in 2011 Oct. 27, 28 using the EAVN, which consists of the Yamaguchi 32-m, Ibaraki (Hitachi) 32-m, Usuda 64-m, VERA 20-m four stations, and Shanghai 25-m radio telescope. As a result, we obtained new VLBI maps for all of the observed sources, and the spatial morphology was classified into five categories on the basis of the classification by Bartkiewicz *et al.* (2009): three sources in elliptical; five in arched; six in linear; nine in isolated pairs; and nine in a complex morphology. In three sources, the methanol maser in G6.795−0.257 showed a clear elliptical morphology (left-panel in figure 1) with a radial velocity gradient on the ellipse. On the basis of the rotation model fitting suggested by Bartkiewicz *et al.* (2009), this maser was well fitted as rotation with infall components of 2.1 km s^{-1}, and may be the best target to detect rotational/infall proper motions.

On the basis of spectral energy distributions (SEDs) estimated from the online fitting tool (Robitaille *et al.* 2006) using infrared data (e.g., right-panel in figure 1), our observed sources are distributed in each evolutionary phase of central YSOs in a range of 10^3–10^6 yr. Our future measurement of the three-dimensional dynamics will yield information about the evolution of the accretion disk around high-mass YSOs.

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