Cosmic Masers: Proper Motion toward the Next-Generation Large Projects
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High-cadence 6.7 GHz methanol maser monitoring observations by Hitachi 32-m radio telescope

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Abstract. We started high-cadence monitoring observations of 6.7 GHz methanol masers from Dec. 2012 using Hitachi 32-m radio telescope (Yonekura *et al.* 2016). Observations have been conducted basically every day. On average, 13 hours of observations have been made per day, amounting to 4000–5000 hours per year. The cadence varies by sources: one observation in 1–50 days. In addition to already known 29 sources (Tanabe et al. 2023 and references therein), we have newly identified ∼20 sources with periodic flux variability. We have also detected 5 sources with sudden flux rises in 2019–2022, including G358.93−0.03 which was confirmed to be associated with the accretion burst.

Keywords. masers, stars:formation, stars:massive, stars:flare

1. Introduction

Almost all 6.7 GHz methanol masers are known to be associated with high-mass protostellar objects. After the discovery of this maser in 1991, more than 1000 objects associated with this maser are detected. Because this maser is pumped by the radiation from the central star, the flux density of this maser was thought to be somewhat stable. In 2003, the periodic flux variability for this maser sources G9.62+0.20E is reported. Until now, 29 maser sources with periodic flux variability have been found. Five mechanisms for the flux variability are suggested. In three of which, the temperature of the dust grains can be changed: (i) rotation of spiral shock wave in the gap of the circumbinary accretion disk, (ii) periodic accretion of material from the circumbinary disc, and (iii) pulsation of the central star. In the remaining two, the flux of seed photons can be periodically changed: (iv) a colliding wind binary, and (v) an eclipsing binary. Aside from the periodic flux variability, non-periodic sudden flux rises with the factor of 10–1000 were detected for 4 maser sources (S255IR-IRS3, NGC 6334 I-MM1, G358.93−0.03, G24.33+0.14). These sudden flux rises were confirmed to be the results of the accretion burst from the observational results of the brightening of the central sources in NIR/FIR/(Sub-)mm.

We started high-cadence monitoring observations of 6.7 GHz methanol masers from Dec. 2012 using Hitachi 32-m radio telescope named "Ibaraki 6.7 GHz class II methanol maser database (iMet)†", in order to detect periodic flux variations and sudden flux rises. In this paper, we briefly summarize the observations and results obtained by iMet.

† All the data are available at iMet (Ibaraki 6.7 GHz class II methanol maser database) web at http://vlbi.sci.ibaraki.ac.jp/iMet/

Table 1. Input catalogs for the "master catalog".

Name of the Input Catalog	Reference	Region
Parkes methanol multibeam survey	Caswell *et al.* 2010	$345 < L < 6$
	Green *et al.* 2010	$6 < L < 20$
	Green *et al.* 2012	$186 < L < 330$
Arecibo Methanol Maser Galactic Plane Survey	Pandian *et al.* 2007	$35 < L < 54$
Compilation catalog at 2009	Xu *et al.* 2009	

2. Observations

2.1. *Target selection*

At first, we have compiled the "master catalog" from the papers listed in Table 1. Then, we have selected 442 sources with Decl. ≥ -30 deg as targets for the monitoring observations at Ibaraki.

2.2. *Observations*

Observations are made using the Hitachi 32-m radio telescope of Ibaraki station, a branch of the Mizusawa VLBI Observatory of NAOJ. Integration time is 5 min. Bandwidth is 8 MHz, centered on 6668 MHz (the rest frequency of the methanol maser is 6,668.5192 MHz). This corresponds to the velocity coverage of $\sim$360 km s^{-1}. Note that the velocity coverage is not centered at $V_{\rm lsr} = 0$ km s^{-1} because the doppler corrections are not performed during the observation. The bandwidth of 8 MHz is divided into 8192 ch, resulting the velocity resolution of $\sim$0.044 km/s. The system noise temperature including atmosphere is $\sim$25 K (zenith) – $\sim$40 K (EL = 15 deg). The typical 1-sigma rms noise level is $\sim$0.3 Jy. The half-power beam width is $\sim$4.6 arcmin with the pointing accuracy better than $\sim$30 arcsec. No real-time pointing corrections are applied. In order to minimize the reduction of the measured flux density due to the pointing error, observations of each sources are executed at the same azimuth and elevation angle. Observations are made by using a position-switching method with the OFF position of ΔR.A. = 60 arcmin or -60 arcmin.

The observation have started from Dec. 2012. Observations are divided into 3 periods: (1) 2012/Dec./30 – 2015/Aug./24: 442 sources are divided into 9 groups (1,2,...,9) and each group is observed once per $\sim$9 days (2) 2015/Sep./18 – 2017/Mar./07: 154 sources showing variability are selected from the results of period (1) and divided into 4 groups (A,B,C,D). Each group is observed once per $\sim$4 days. The rest 288 source are not observed. (3) 2017/Jun./14 – now: 442 sources are observed with the hybrid of (1) and (2), i.e., using the sequence of [1ABCD2ABCD3ABCD...8ABCD9ABCD].

3. Results

We have newly identified $\sim$20 sources with periodic flux variability in addition to already known 29 sources. We have also detected 5 sources with sudden flux rises in 2019–2022, including G358.93−0.03 which was confirmed to be associated with the accretion burst.

4. Acknowledgement

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Group photo of the Maser Monitoring Organisation (M2O). Taken by Ka-Yiu Shum.

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