PROCEEDINGS OF SCIENCE

Multiepoch observation of periodic methanol maser in G107.298+5.639

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In recent years a small group of methanol maser sources showing periodic variability have been identified. There is ongoing discussion on causes of this type of behavior, but none of the explanations are satisfactory. Discovery of source G107.298+5.639 showing alternating and periodic flares of 6.7GHz methanol and 22GHz water vapor masers can give us a clue to processes leading to observed periodicity. Recently we confirmed OH maser periodicity in this object. Result of multiepoch EVN observations of methanol emission in G107.298 will be presented.

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1. Introduction

Class II 6.7GHz methanol masers are one of the most abundant maser populations that are associated with forming regions of high mass young stellar objects (HMYSO) , and are thought to occur in most inner regions of protostellar environment. Due to its nature, this emission is highly sensitive to local changes in physical properties especially variations in IR flux which is responsible for pumping of the maser population.
Recent long-term monitoring efforts have highlighted the existance of small group of 25 sources showing periodic flares. The periods range from 24 to 668 days and behavior differs for each source. The flare profiles can be divided into 3 groups: asymmetric and symmetric sinusoids with almost no quiescent time during one cycle, and mostly symmetric gaussian bursts that last only a fraction of single period of activity. This behavior is usually visible in all emission of the source with some cases showing significant delays between spectral features. There are also examples of sources that show periodic flares only in part of its spectrum.
Due to variety in this small group of sources there are many models created in attempt to explain mechanism driving this variability. They can be divided into two groups, first are models that assume that maser flares are just amplified changes in background seed photon flux and physical properties in maser itself are not changing. Among those models the most widely approved is Colliding Wind Binary model (CWB) [11]. Other group of models states that visible variability arises due to change in pumping efficiency in maser itself. This change can be easily caused by many processes that are known to occur during accretion of matter onto protostar. The models in this group are: periodic accretion o a protostar [1], pulsation of HMYSO [4], rotation of hot spiral shock waves in the central gap of circumbinary accretion disc [7] and superradiance [8]. All of mentioned models can be used to explain behavior of some sources but there is no easy way to determine which one of them is really taking place.
In 2016 we reported that known periodic source P=34.4d [3] G107.298 + 5.639 (G107 hereafter) displays alternating flares of the 6.7 GHz methanol and 22GHz water emission [10]. In monitoring data it is clearly visible that water emission is being suppressed while methanol flare is taking place. When 6.7GHz line falls below detection limit, 22GHz emission starts to increase in intensity. This is the first and to this day only source that displays such variability. Since water maser is pumped by shocks there should be no correlation between both line behavior, but if both emissions are spatially adjacent then increased IR radiation could temporally quench 22GHz line while powering 6.7GHz emission. In fact detection of periodic IR flares in this source have been reported [9]. This source could be a rare example when we can distinguish which of different models of periodic variability can be applied. These proceedings present early results from an multiepoch observing campaign investigating behavior and changes in methanol maser emission of G107.

2. Observations

The target was observed at 6.7GHz with European VLBI Network four times: 16th of March 2015, 26th of Feburary, 5 of June and 20th of October 2016 in a phase referencing scheme using J2223+6249 as a phase-calibrator with a switching cycle of 195s on the maser and 105s on the calibrator. The spectral setup was set with bandwidth of 4MHz for 2048 channels yielding velocity

Table 1: A summary of multiepoch EVN observation program targeting G107.

Project Code	Date	Antennas	Resolution (mas)	RMS (mJy)
ES076	16.03.15	Jb,Ef,Mc,O8,Tr,Wb,Ys	5.78 x 3.68	1.5
ES079A	26.02.16	Ef,Mc,O8,Tr,Nt,Wb,Ys,Sr	5.23 x 3.18	3
ES079B	5.06.16	Jb,Ef,Mc,O8,Tr,Nt,Wb,Ys,Sr,T6,Ir	4.16 x 2.84	2.5
ES079C	20.10.16	Jb,Ef,Mc,O8,Tr,Nt,Wb,Ys,T6	4.23 x 3.12	5

resolution of 0.09kms^{-1}. observations were correlated with 0.25s integration for first epoch and 1s for others. The data was reduced using AIPS package following standard procedures for calibration of spectral line observations [2]. The summary of each observation is presented in Table.1. The dates of observations were chosen to map different phases of burst. To supplement EVN observations we used 32m Torun antenna to acquire single dish spectrum.

3. Results

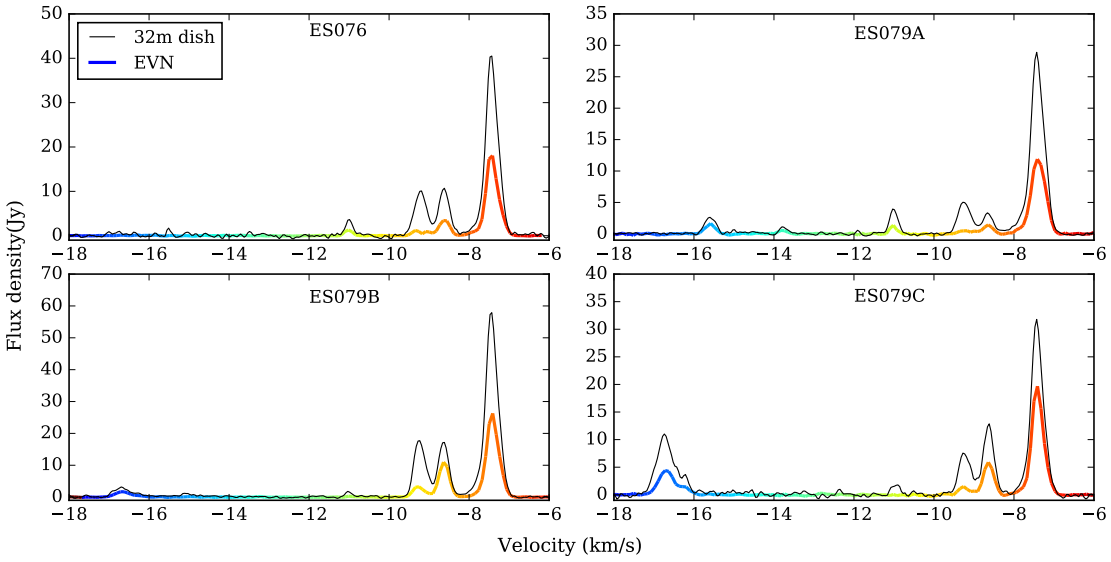

Figure 1: Comparison of methanol maser spectra of the source G107 obtained from each epoch of EVN experiment (colored line) and corresponding single dish observations conducted in the same day (black line). The colors in EVN spectrum are scaled in relation to velocity.

Comparison of EVN and single dish spectra shows that emission is strongly resolved on VLBI resolution with brightest feature showing from 38 to 60 % of flux density seen by Torun antenna Figure.1. Brightness varies for all emission features.
Maps of the source show that most of methanol emission is located in two groups, redshifted and blueshifted contained in regions smaller than 200mas which corresponds to 150AU at distance 764pc. Both regions are separated by ~400mas from each other Figure 2. In experiment ES079A

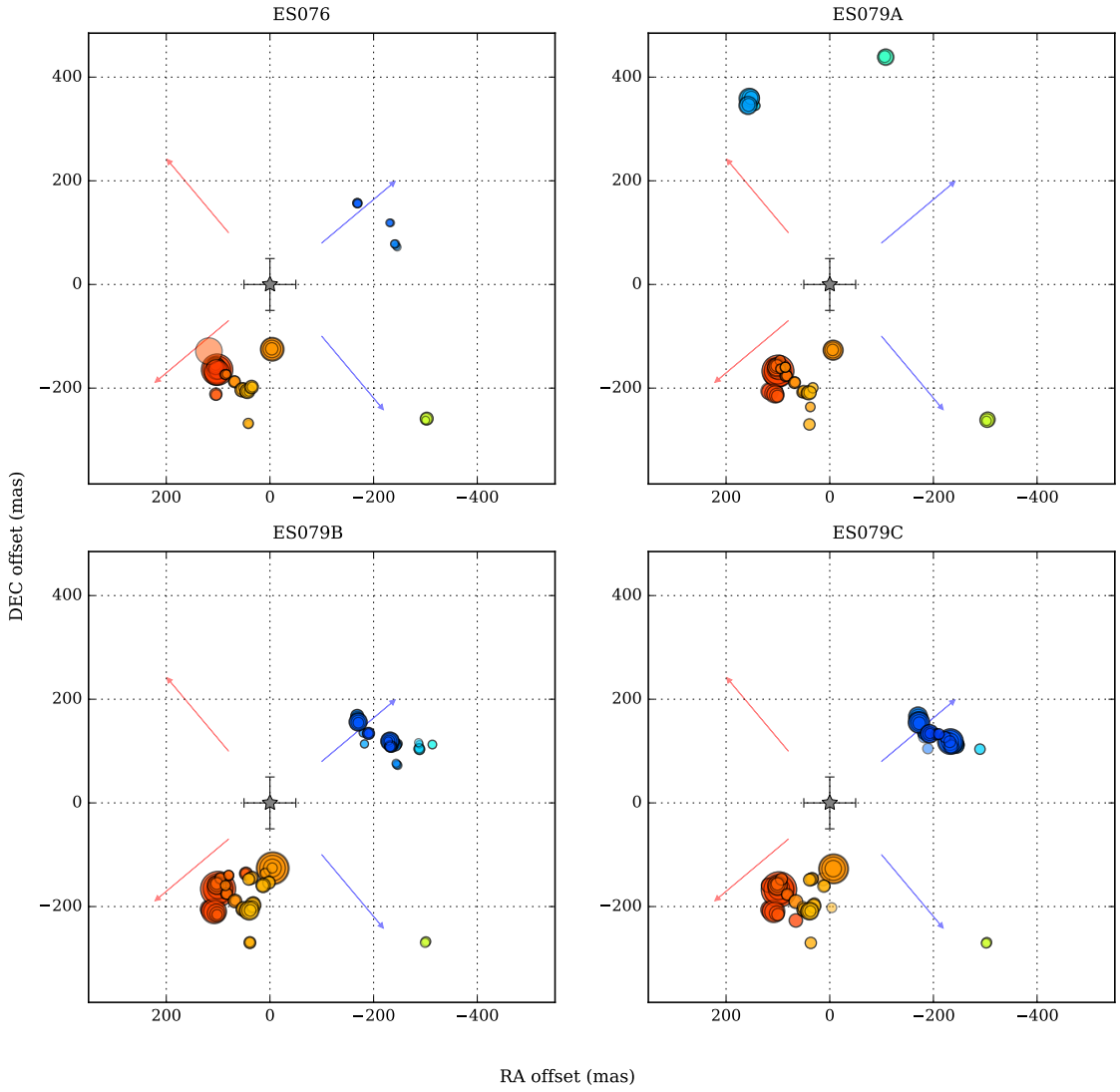

Figure 2: Results of multiepoch monitoring of 6.7GHz methanol maser in source G107. Colors represent velocity scale as seen in Figure.1, size of symbols is scaled with with square root of measured peak flux. Center of map corresponds with absolute position $RA(J2000) : 22^h21^m26.758^s, DEC(J2000) : 63^o51'37.822"$ of continuum peak reported in (ref) marked as the star symbol [5]. Directions of large scale molecular outflows are marked with arrows [6].

the blueshifed group is not visible at its usual location and a new components appeared in northern side of the source, this is due to different phase of flare for those components. Multiepoch 6.7GHz observations allowed us to map emission corresponding to all spectral features visible on one dish data, this would be not possible with single VLBI observation due to significant delays in flares of different velocity components reaching up to 4 days that are most likely caused by line of sight effects. Considerable changes in brightness and structure of individual clouds are visible due to different phases and varied amplitudes from cycle to cycle.

Conclusion: We succesfully conducted multiepoch VLBI observation of periodic methanol maser source G107.298 + 5.639 using EVN network. Maps for four epochs were presented highlighting evolution of emission structure during 2 year period. Masing regions show no significant change in spatial distribution during this time suggesting that mechanism causing periodicity does not disturb local environment.

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