Periodic time variation of the 6.7 GHz methanol maser in Mon R2

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◇◆Abstract◆◇

We perform a single dish observation using Yamaguchi 32 m radio telescope and measure flux of the 6.7 GHz methanol maser in Monoceros(Mon) R2 which is a high-mass star forming region. Previous observation by Yamaguchi 32 m radio telescope showed that the methanol maser in Mon R2 might show a periodic variability with a period of ~23 days. In the present study, we are trying to confirm the periodicity by daily monitoring observation. We report on the preliminary results of the light curve of Mon R2 from May to October 2014.

◇◆Introduction◆◇

The process of massive star formation has not been understood so much. The 6.7GHz methanol maser has been detected only in massive star formation[1]. So far, some 6.7 GHz methanol maser sources have shown the periodic time variation of their flux. The time scale of period ranges are from 29.5 to 668 days, only two sources show the short period (< 100 days). In 2009, Yamaguchi 32 m radio telescope monitored the 6.7 GHz methanol maser in Mon R2 (see Fig.3). The flux varied with long time scale, however a very short time variation may be also found in the past observations (see Fig.4). Probably the period is ~23 days which is the shortest period of 6.7 GHz methanol masers. Because the shortest time variation was not detected clearly by the past Yamaguchi 32 m observations, we want to confirm the shortest time variation is real or not. Thus higher frequent and longer term observation than past observations has started using Yamaguchi 32m radio telescope from this May.

◇◆Mon R2 ◆◇

- High-mass star forming region in the monoceros
- The source located at a distance of 830 pc.[1]
- The VLBI image shows a linear structure(Fig.1).
- Coordinates(J2000):RA 06h07m47.8s Dec -06° 22' 56.5"

◇◆Observations◆◇

We carry out 1 hour daily observation using the Yamaguchi 32 m(including calibration). We measured system noise temperature before or after the observation. To measure an accurate flux, we carry out pointing observations for MonR2 and calibrator(S269).

Table2:Observation parameter

Telescope	Yamaguchi 32 m radio telescope
Observation Frequency	6668.519 MHz
Polarization	R/L circular polarization
Beam size	~5'
Bandwidth	8 MHz
Velocity resolution	0.046 km/s
Integration time	180 s
System noise temperature	40 ~ 80 K

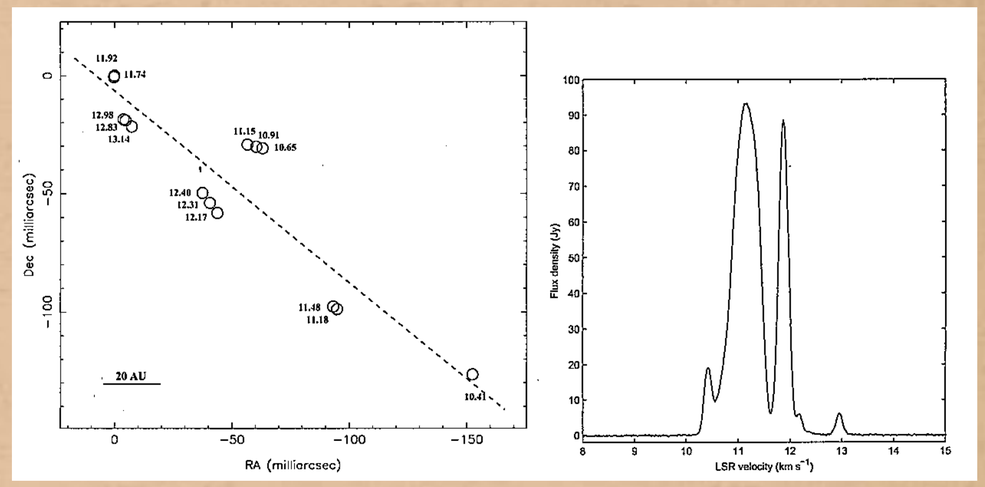

Fig.1:VLBI map and spectrum(V.Minier et al 2000)

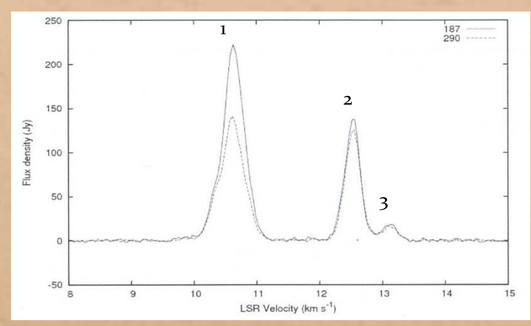

Fig.3:Spectrum in 2009

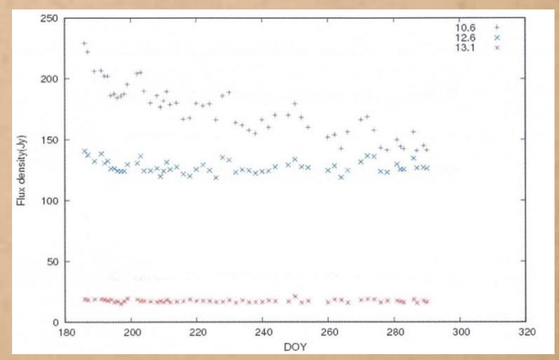

Fig.4:Light curve in 2009

◇◆Preliminary result◆◇

We started the daily observations for the 6.7 GHz methanol maser in Mon R2 from this May 7 and the observation will be finished at the end of this December. Here we report the preliminary results of the observation from May 7 to October 12 (see Fig.6). Fig.5 is a spectrum of Mon R2 obtained observed at May 21. Fig.6 shows the flux time variation of two stronger maser components. Fig.7 shows the peak flux density was normalized by flux calibrator(S269) and the result of fitting as the results periodicity is as follows.

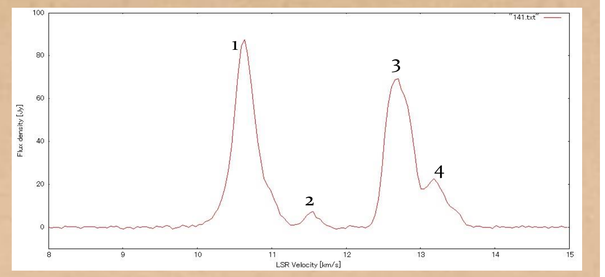

Fig.5:Spectrum in May 21

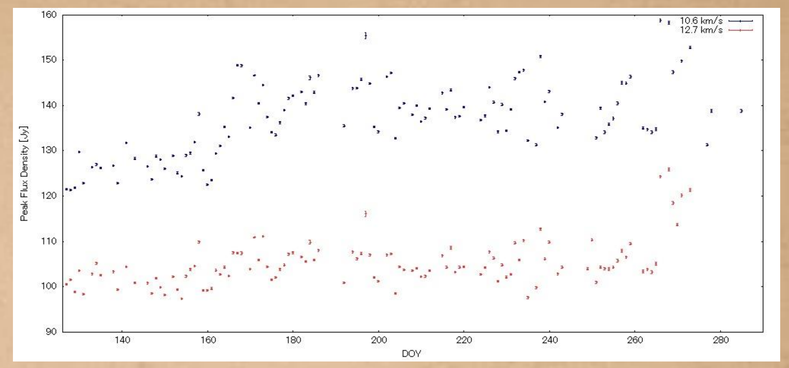

Fig.6:Light curve in 2014

Component1:23.3 ±0.01 [days]

Component3:23.8 ±0.02 [days]

In addition, components 1 and 3 showed the variation is similar.

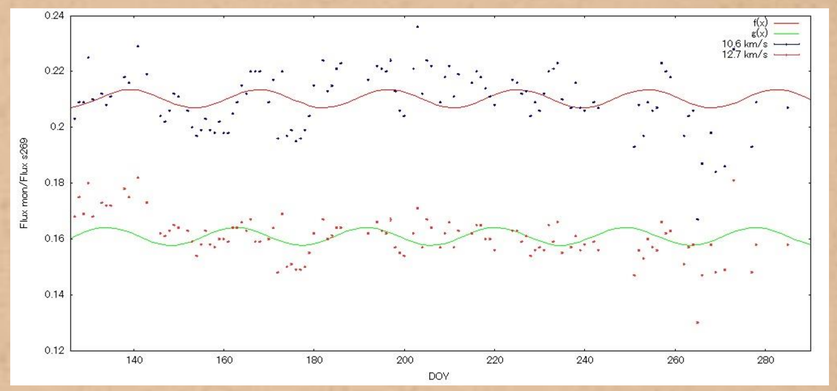

Fig.7:Result of periodicity fitting

◇◆Discussion◆◇

Time scale of the variation in Mon R2 was 23 days which is the shortest in the known methanol maser with periodic variation. In addition, it seems to be synchronized with other spectral component. We think that this is caused by the something by the central protostar. Pulsation model can be considered as a cause of the periodic variation[2]. The model can explain the intensity variation of the period of 10 to 100 days. There is a time when size becomes unstable at the stage of evolution of the protostar of over $10^{-4}M_{\odot}$/yr. The protostar pulsates with a period of more than 10 days.

◇◆Future work◆◇

- Continue observation of Mon R2 until the end of December, and analyze the data.
- Analysis of other components.
- Explain time variation by various models.

◇◆Reference◆◇

[1]V.Minier, R.S. Booth, and J.E. Conway Astron. Astrophys. 362, 1093-1108 (2000)

[2]Kohei Inayoshi, Koichiro Sugiyama, Takashi Hosokawa Kazuhito Motogi, and Tanaka, Kei E.I.T.anaka The Astrophysical Journal Letters, 769:L20(5pp), 2013 June 1