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Global outburst of methanol maser in G24.33+0.14

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Abstract. A strong outburst of 6.7 GHz methanol maser occurred in the high-mass young stellar object (HMYSO) G24.33+0.14 between November 2010 and January 2013. The target was observed with the Torun 32 m radio telescope as a part of a long-term monitoring programme. Almost all twelve spectral features from 108 to 120 km s^{-1} varied synchronously with time delays between the flux minima of about two weeks. This may indicate that the variability is driven by global changes in the pump rate. The flare peaks of the two features with the highest relative amplitude of 40-60 are delayed by about 2.5 months while their profiles undergo essential transformation with a velocity drift of 0.23 km s^{-1}yr^{-1}. This may suggest that the variability is caused by a rapid increase of the pump rate and excitation of a large portion of the HMYSO environment by an accretion event.

Keywords. masers, stars: formation, ISM: clouds, radio lines: ISM

Target. G24.33+0.14 is a single high-mass hot core associated with the hydroxyl, methanol and water masers (Caswell & Green 2011). The 1667 MHz OH masers extending over more than 20 km s^{-1} differs by as much as 50 km s^{-1} from the systemic velocity suggesting that it arises in a unique strong blueshifted outflow. The spatial coincidence of methanol and water masers with the OH emission strongly suggests that all three maser species are excited by a single HMYSO.

Maser outburst. The source experienced remarkable synchronised flares lasting 200 −400 days (Fig. 1). For instance, from MJD 55466 to 55780 the emission at 115.36 km s^{-1} rose by a factor of 57. This extreme flare was preceded by two weaker bursts peaked at MJD 55314 and 55793 with relative amplitude of 2.7 and 12.7, respectively, and followed by two faint bursts around MJD 56013 and 56122 with relative amplitudes of 3.3 and 0.9, respectively. The feature profile changed during the brightest flare showing a velocity drift of −0.1 km s^{-1}yr^{-1}. The minimum, start, peak and end of the flare were estimated for each maser feature using a synthetic curve which is the best fit of a sum of several Gaussians and one linear function to the data. The minima and peaks are measured directly from the synthetic curve. The start/end of flaring event is the first data point after the minimum/maximum where the flux density is more than 1σ above the quiescent flux density. Figure 1 (Right) and Table 1 give the parameters of flare events for 12 maser features. The mean rise and decline phases of the flare lasted 249 and 312 d, respectively. There is a significant scatter of the times of the events; the times of peaks and ends of flares of individual features differ by 4 and 15 months, respectively. This suggests that the variability is caused by changes in the optical depth of the maser transition that can be related to an accretion event. The observed characteristics of the burst are very similar to those observed for S255 NIRS 3 (Moscadelli *et al.* 2017). If we assume that the time delay between the light curve minima of 2×σ(minimum mean)=10.2 d is attributed to the light travel time then we can estimate a linear size of the source of 1900 au. This

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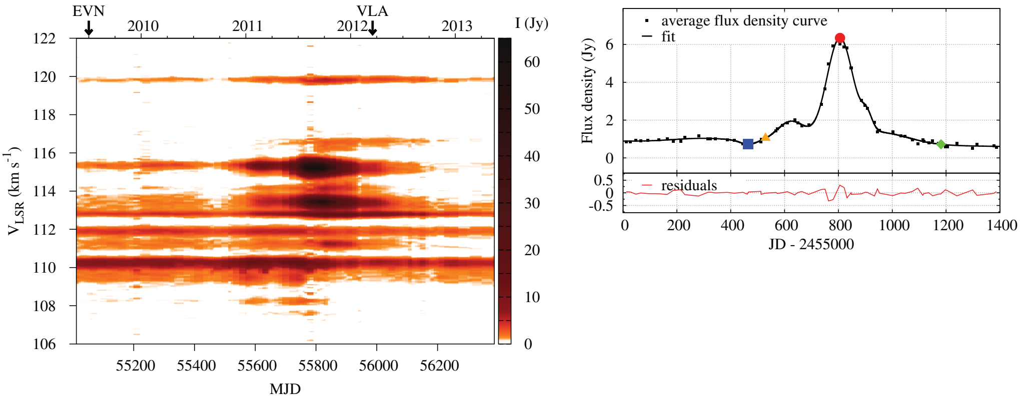

Figure 1. *Left:* Dynamic spectrum of the outburst in G24.33+0.14. The arrows above the upper horizontal axis mark the observations of 6.7 GHz maser emission with the EVN (Bartkiewicz *et al.* 2016) and VLA (Hu *et al.* 2016). *Right:* Flux density curve averaged over the whole velocity range. Times of minimum (square), start (triangle), peak (circle) and end (diamond) are marked.

Table 1. Statistics of flare events. SE and SD denote standard error and standard deviation, respectively.

Event type	mean MJD	SE (d)	SD (d)
Minimum	55470.0	5.1	17.1
Start	55548.7	8.5	28.25
Peak	55797.3	14.9	49.3
End	56109.4	53.4	177.0

value is close to an upper limit of methanol source size (Bartkiewicz *et al.* 2016). High angular resolution observations of 6.7 GHz maser emission (Bartkiewicz *et al.* 2016, Hu *et al.* 2016) have revealed that the angular size of the source is 0.5 arcsec. Thus, for the assumed kinematic distance of 7.7 kpc (Caswell & Green 2011), the linear size of the source would be as large as 3900 au. Our estimate of linear size of 1900 au implies much shorter distance of 3.7 kpc. The emission is highly resolved out when observed with the VLBI beam of 6$\times$5 mas but it is fully recovered with the VLA. It may reflect an intrinsic property of this peculiar source or indicate that the distance adopted in the literature is overestimated.

Conclusions. (i) A global outburst of 6.7 GHz methanol maser of $\sim$1.5 yr duration occurred in G24.33+0.14. (ii) The relative amplitude of maser intensity was up to 40$-$60. (iii) It is suggested that maser outburst was induced by a rapid increase of the pump rate.

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