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Variability studies of 6.7 GHz methanol masers at HartRAO

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Abstract. A program monitoring the variability of a sample of 56 6.7 GHz methanol masers was started in December 1998. The sources are observed on a weekly basis. We present preliminary results of the monitoring program.

1. Introduction

The 6.7 GHz methanol masers appear to be excellent tracers of massive star formation (Caswell et al. 1995a). While the exact evolutionary phase of the stars associated with the methanol masers is not known, it is clear that they are very young (Norris et al. 1998). Therefore studies of the masers can lead to greater insight into processes involved in massive star formation. A study of the variability of the masers can be used to examine changing conditions in the star formation region. A number of masers have been found to be variable (Caswell, Vaile & Ellingsen 1995).

To date, an intensive study of the variability of 6.7 GHz methanol masers has not been done. Previous studies have looked at a small sample of masers for a short time, or with intervals between observations on the order of several months. Observations of G351.78-0.54 show rapid variations on a timescale of months (MacCleod & Gaylard 1996) when the maser is in its most active phase. Other masers appear to be unchanged over the same timescales. Regular monitoring will be able to give us an idea of how common maser variability is and the typical timescales of variability. The variability data can also be used to test maser models. The cause of variability could be dependent on the maser location with respect to the associated star. The masers could be in circumstellar disks (Norris et al. 1998), outflows, shock fronts, or simply in random locations within the star forming region. The variability could be as a result of motions in the cloud, shocks, changes in intrinsic brightness of the star, changes in the pumping mechanism or quenching of the maser region. Some of the variations may be extrinsic eg. interstellar scintillation.

A monitoring program using the Hartebeesthoek 26 m telescope was started in December 1998. A sample of 56 sources was selected, which are observed once

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a week when possible. If a source is seen to be varying rapidly, observations are made at 2–3 day intervals. Table 1 gives a list of the sources being monitored and an indication of the degree of variability. The variability measure is given by the difference between the variance of the time series of a peak and the variance of the time series of a noise channel, divided by the average flux of the peak.

Name	Variability	Name	Variability
174.20–0.08	0.03	339.62–0.12	0.37
213.71–12.60	0.94	340.79–0.10	0.40
189.03+0.79	0.02	339.88–1.26	0.39
188.95+0.89 *	0.15	344.23–0.57	0.03
192.60–0.05	0.04	345.50+0.35	0.12
196.45–1.68	0.05	345.00–0.22	0.11
287.36+0.64 *	0.02	348.55–0.98	0.05
291.27–0.71	0.03	NGC6334F *	0.80
294.52–1.62	0.18	351.58–0.35	0.01
298.26+0.74	0.00	351.78–0.54	1.45
305.21+0.21	0.04	354.61+0.47 *	0.06
308.92+0.12	0.02	359.61–0.24	0.30
309.92+0.48 *	0.32	9.62+0.2 *	1.85
312.11+0.26	0.02	W31	0.03
316.64–0.09	0.17	10.33–0.17	0.06
318.95–0.2 *	0.05	12.89+0.49 *	0.07
320.23–0.29	0.06	W33A	0.53
322.16+0.64	0.26	W33B	0.06
323.77–0.21 *	0.73	23.44–0.18	0.12
328.81+0.63	0.05	23.01–0.41	0.08
328.24–0.55	0.21	35.20–1.74 *	1.30
331.13–0.24	0.61	45.07+0.13	0.02
331.28–0.19 *	0.03	52.668–1.09	0.10
335.55–0.31	0.01	59.78+0.06	0.00
336.01–0.82	0.12	W75N	0.83
336.99–0.03	0.01	69.54–0.98	0.02
337.92–0.46	0.01	75.77+0.34	0.19
338.93–0.06	0.07	78.12+3.63	0.26

Table 1. List of sources being monitored and variability measure calculated for the period between December 1998 and May 2000. The variability measure of the most variable peak in each source is presented. Sources marked with a "*" are also being monitored at 12.2 GHz (see Gaylard, Goedhart & Dhlamini, this volume).

2. Variability in G9.62–0.20

G9.62-0.20 is an interesting example of variability, exhibiting correlated variations in different peaks and pseudo-regular flares. Phase lags will be seen when

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a 'disturbance' progresses through a maser site, from one spot to another. This phase lag information, together with spot maps of the features, can be used to trace the direction and origin of the disturbance.

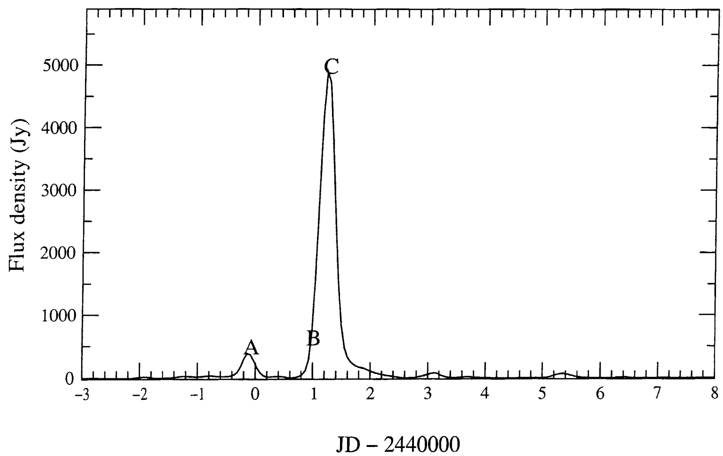

Figure 1. Averaged spectrum of G9.62–0.20.

Figure 1 shows the averaged spectrum of this source. The flare at feature B appears to lag the flare at feature C by 20 days. See Figure 2 for a contour plot of the entire time series. The phase lags can be clearly seen in this plot. The discrete correlation function (Edelson & Krolik 1988) between these two velocity channels shows strong aliasing. This is typical of a periodic variation with a phase lag. A discrete Fourier transform (Scargle 1982) gives a power spectrum with peaks spaced at equal intervals, indicating a non-sinusiodal, periodic ignal. Only four flares have been observed so far, giving us 3 complete cycles. This is not conclusive evidence of a periodic flare, but the numerical analysis presents a strong case for periodicity. A longer time series will be necessary to confirm this. The interval between flares appears to be 240 ± 20 days with the peak of the last observed flare occuring at the end of February 2001.

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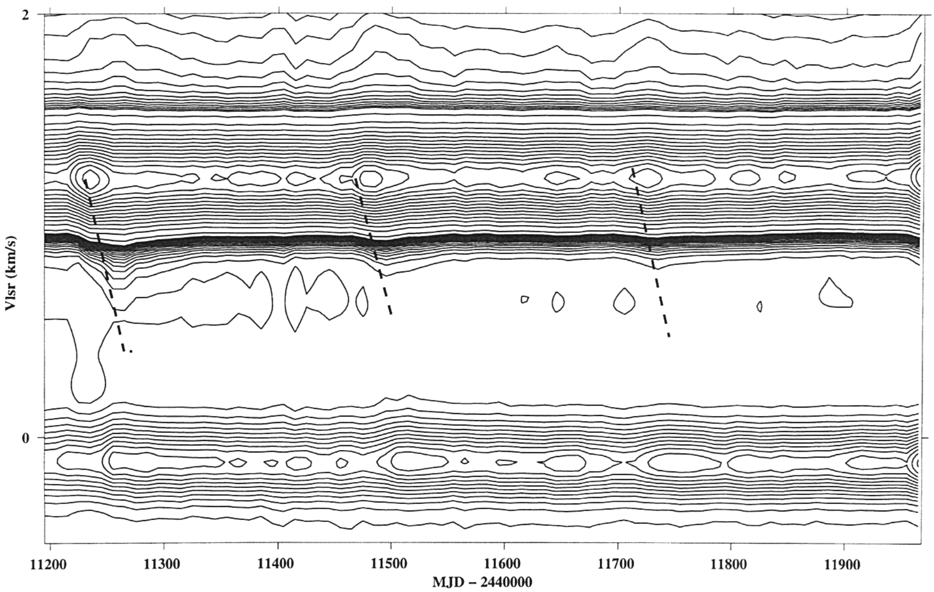

Figure 2. Contour graph showing time series of G9.62–0.20. The countours show the intensity of the maser. The time is on the x axis and velocity along the y axis. The dashed lines indicate the progression of the flares.

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