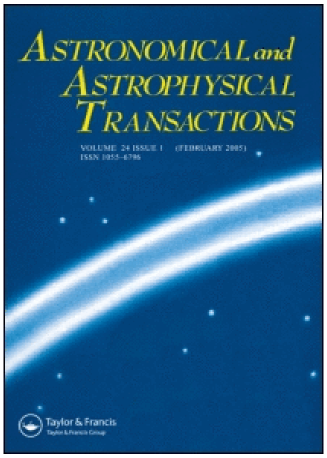

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Results of a search for ultrarapid flux fluctuations of galactic water maser sources at the wavelength 1.35 cm

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The results of a search for ultrarapid variability of galactic water maser sources at the wavelength 1.35 cm on a timescale of several minutes to 1 h are reported. A special observational technique was developed. Using this technique, several observational sessions for more than 30 maser sources were carried out from 2002 to 2006. Among those, several sources that have shown such variability were found. The causes of this are discussed. The most interesting of these causes are internal processes within the sources ongoing in regions with a characteristic size of about 0.1 AU. Clear evidence for such a variability type was found in at least two sources: W49N and W33B. Variability of this kind displays itself only in certain states of the water masers.

Keywords: Star formation; Molecular lines; Masers; Intraday variability

1. Introduction

Since the discovery of cosmic maser sources that radiate in the water vapour spectral line [1] their temporal variability has been studied more than once (see, for example, [2–6]). In this contribution we report the results of a search for ultrarapid fluctuations in the flux densities of galactic maser sources in the water vapour line at the wavelength 1.35 cm. At present we know that the following features exist:

(i) long-term cycles in flux variations of water maser sources (they were described for the first time in the papers by our joint team (see, for example, [5, 6]));
(ii) flare activity on a timescale of months, which has been known since the discovery of water masers [2, 3];

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(iii) some features which double their fluxes in 2.4 days [7];
(iv) ultrarapid variations on timescales of an hour or shorter, or 'intraday variability' [8].

The last type of variation was detected for the first time in megamasers, namely in the galaxy IC 10. The water maser in IC 10 doubled its flux during 1 h [8]. We have set ourselves the task of detecting similar processes in galactic water masers at $\lambda = 1.35$ cm.

2. Observations

Our observations for the water line at $\lambda = 1.35$ cm were performed in several observational sessions in 2002–2006 on the 22 m radio telescope at the Pushchino Radio Astronomy Observatory (Astro Space Center of the Lebedev Institute of Physics, Russian Academy of Sciences). We use a 1.35 cm wavelength receiver with a helium-cooled field-effect transistor amplifier and a 128-channel filter-bank spectrometer with a resolution of 0.1 km s^{-1}. Since December 2005 we also used for spectral analysis of the signal a 2048-channel autocorrelator with a total bandwidth of 168.5 km s^{-1} and a velocity resolution of 0.082 km s^{-1}. We observed in total about 30 water maser sources.

The problems of the detection of ultrarapid variations (on timescales of an hour or shorter) are as follows:

(i) inaccurate telescope pointing, where the beam may 'drift' as far as $\pm 1'$ owing to the changing relative positions of the Sun and telescope in fine weather;
(ii) the strong dependence of the measured flux density on the source elevation due to absorption in the Earth's atmosphere;
(iii) the strong dependence on weather conditions, especially on the absolute humidity;
(iv) calibration problems, and the absence of bright reference radio sources;
(v) scintillations on interstellar plasma irregularities on timescales of 0.5–1 h.

As a result, even the best telescopes provide under perfect conditions a calibration accuracy of the order of 5%. However, it can be noted that all these effects influence the entire spectrum simultaneously. Meanwhile, it is well known that in cosmic masers the emission in spectral features is generated by a cluster of maser condensations spanning over tens, hundreds and even thousands of astronomical units (see, for example, [9]). Therefore, rapid fluctuations, if present, can manifest themselves in a small number of spectral features, which do not affect the other features. We have proposed a method of self-calibration; we measured only the variations in the relative weights of individual spectral features with respect to the total flux:

$$\Delta\,[\mathrm{Flux}_v(t)] = \frac{\left[\sum_{v_i=V_1}^{v_i=V_2} \mathrm{Flux}_{v_i}(t)\right] / \mathrm{Flux}_{\mathrm{total}}(t)}{\left[\sum_{v_i=V_1}^{v_i=V_2} \mathrm{Flux}_{v_i}(t_1)\right] / \mathrm{Flux}_{\mathrm{total}}(t_1)}, \qquad (1)$$

where V_1 and V_2 are the boundaries of the spectral range, t_1 is the time of the first observation in the series and $\Delta[\mathrm{Flux}_v(t)]$ closely corresponds to the real flux change in some spectral features. Thus, the majority of the above problems have been removed.

Among about 30 masers observed, we have selected several sources that have displayed rapid flux variations. We discuss the cause of such variations; the most interesting are processes within the sources themselves, in regions with a scale of about 1 AU. Probably, we have detected this kind of variability in at least two sources: W49N and W33B (figures 1 and 2). W33B displayed an obvious change $\Delta[\mathrm{Flux}_v(t)]$ (equation (1)) of between 70% and 200% for different spectral features on a timescale of 5–10 min in March and April 2006. Before this epoch (2002–2006) and after (May 2006), the changes were only 10–20% and less. W49N usually showed changes $\Delta[\mathrm{Flux}_v(t)]$ of 3–4% for different spectral features (figures 1(b) and 2(b)) on a timescale of 5 min to an accuracy of about 0.3–0.5%. However, we obtained a single observation on 28 March 2003 with changes between 10% and 40% for different spectral features on a 10–20 min timescale.

The following causes for the variations are possible.

(i) The linear polarization of some spectral features results in flux variations of some features on a timescale of a few hours. The method to overcome this is to store data on an extended interval of unchanged projected position angles of the polarization on several consecutive days. Then, by comparing the obtained time series, we eliminate identical diurnal trends in the fluxes.

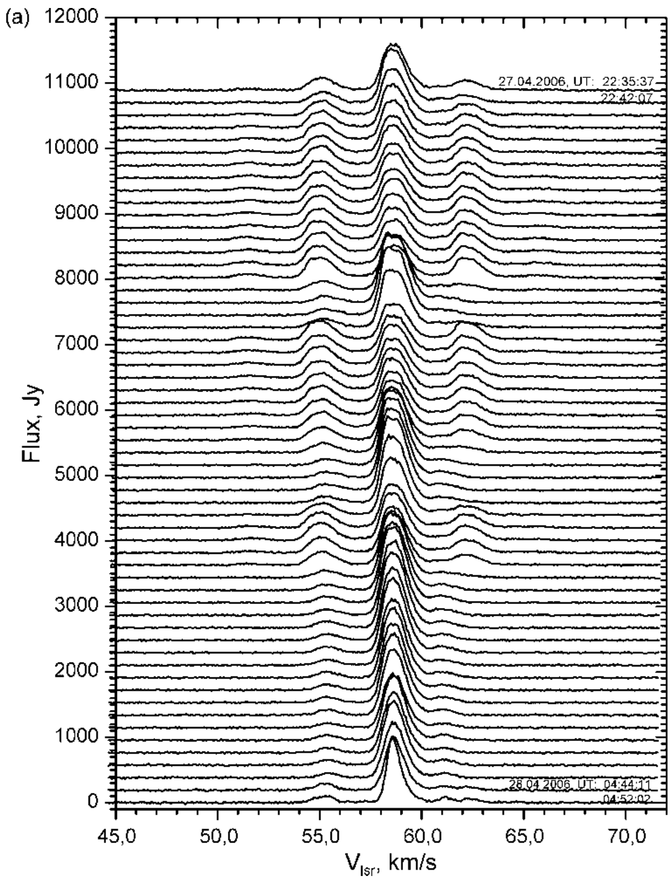

Figure 1. (a) Water observations of the source W33B: 58 spectra in total; 6 min exposures; 27–28 April 2006 (Universal Time (UT) 22:35:37 to 04:52:02). (b) Water observations of the source W49 N: 32 spectra in total; 4 min exposures; 27 March 2006 (UT 08:31:15 to 10:41:05). In each graph the vertical scales for all profiles are the same, but for clarity the profiles are shifted with respect to the baseline.

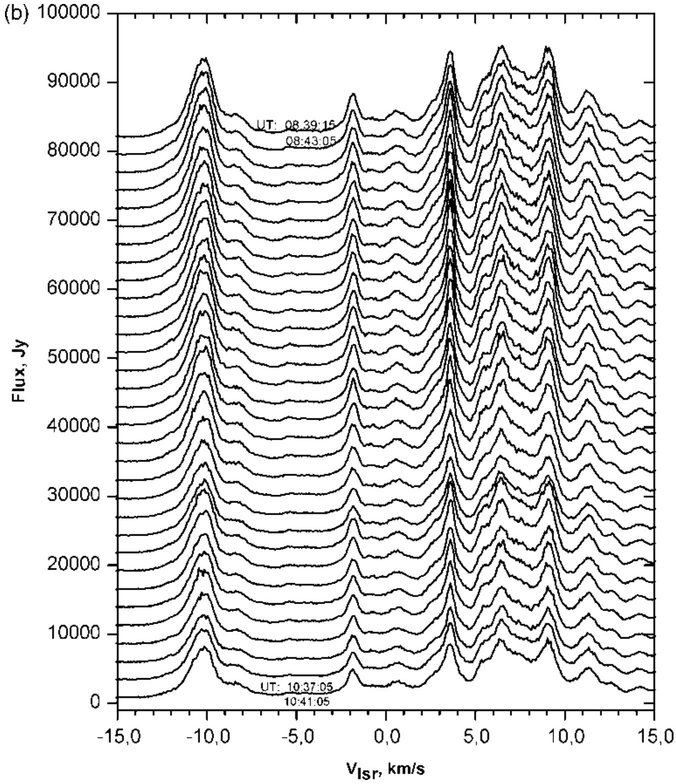

Figure 1. Continued.

(ii) Some sources have a complex structure, i.e. include several maser spots within less than 2′, whereas our beam width is 2.6′. The telescope pointing must be carefully checked, and such sources should be discarded.
(iii) Intrinsic variability of individual spectral features, which is caused by fast internal processes in the sources on scales of a fraction of an astronomical unit is what we are searching for.

3. Main results

We have observed about 30 sources with exposures from 1.5 to 12 min with the number of scans for each source not fewer than ten. We selected sources with the maximum flux density in the line not lower than 100 Jy. Our findings are as follows.

(i) For fainter sources of our sample we can achieve with RT-22 an accuracy better than 5–10% on exposures (integration times) shorter than 5 min. Such sources can be used in a search for variations on timescales of about an hour.
(ii) For sources with bright features (W49N, Ori A, Cep A, W3OH, W51M, VY Cma and IRAS 16293-2422) we have achieved an accuracy of 3–0.5% on exposures as short as 1.5 min.

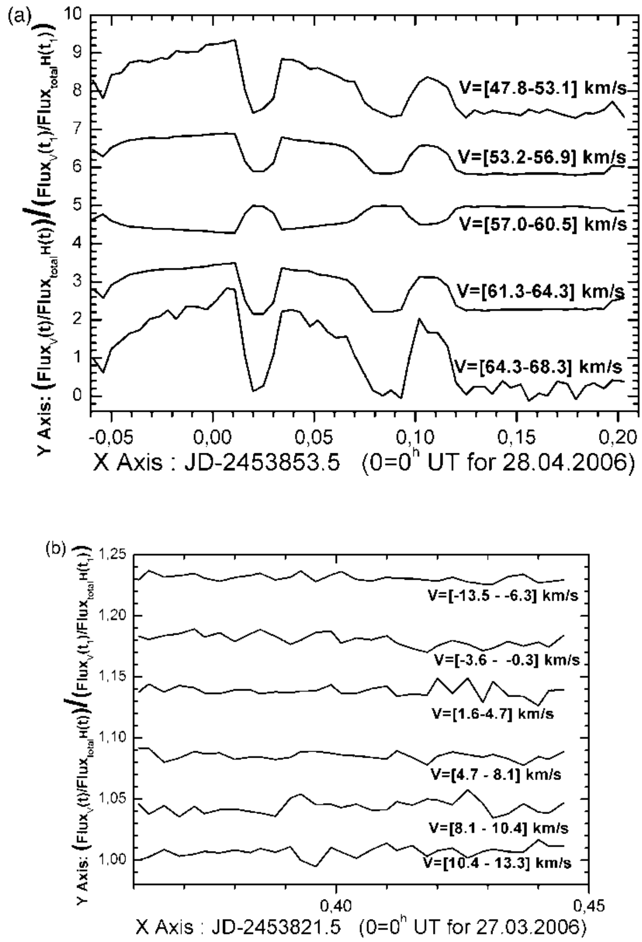

Figure 2. The changes $\Delta[\mathrm{Flux}_v(t)]$ (equation (1)) for (a) W33B and (b) W49N, for data from the corresponding parts of figure 1.

(iii) Some sources (Ori A, W3 OH) demonstrated in selected features obvious variations by 10–30% on timescales of 2–3 h. In W49 N and W33B we detected variations of the order from 2–3% to tens of the percent on timescales of 2–25 min. This suggests the existence of compact condensations with a size of a tenth of an astronomical unit, and possibly of a few hundredths of an astronomical unit.

(iv) As a byproduct, our method allows us to estimate the degree of linear polarization of water spectral features and, from the comparative correlation analysis, their spatial association.

Acknowledgements

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References

[1] S.H. Knowles, C.H. Mayer, A.C. Cheung *et al.*, Science **163** 1055 (1969).
[2] S.H. Knowles, C.H. Mayer, W.T. Sullivan *et al.*, Science **166** 221 (1969).
[3] W.T. Sullivan, Astrophys. J. Suppl. Ser. **25** 393 (1973).
[4] I.I. Berulis, E.E. Lekht, M.I. Pashchenko *et al.*, Astron. Zh. **60** 310 (1983) (Engl. transl., Sov. Astron. **27** 179 (1983)).
[5] I.I. Berulis, E.E. Lekht, V.A. Munitsyn *et al.*, Astron. Zh. **75** 394 (1998) (Engl. transl., Astron. Rep. **42** 346 (1998)).
[6] V.A. Samodurov and S.V. Logvinenko, Astron. Zh. **78** 396 (2001) (Engl. transl., Astron. Rep. **45** 339 (2001)).
[7] P.R. Rowland and R.J. Cohen, Mon. Not. R. Astron. Soc. **220** 233 (1986).
[8] R. Genzel, D. Downes, J.M. Moran *et al.*, Astron. Astrophys. **78** 239 (1979).