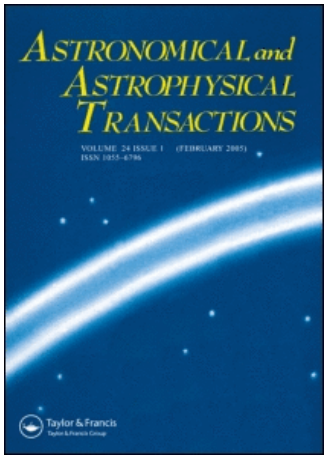

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ON THE CYCLIC ACTIVITY OF H_2O MASERS IN STAR FORMATION REGIONS

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Data on the time variability of maser sources of the H_2O lines in star forming regions are analyzed. We find three types of variability at timescales of four to ten years: sinusoidal, periodic with variable amplitude, and alternating active and quiescent states. The long-term variability of H_2O masers may be due to non-stationary accretion onto the stars being born.

KEY WORDS Interstellar medium, star formation, masers

It is well known that during early stages of their evolution ($< 10^4$) years) stars are unstable and may change strongly their luminosity. The unstable state of a star is related to the non-stationary accretion of matter onto the star during the process of its formation. Theoretical studies have shown that this accretion may give rise to oscillations of stellar brightness with periods of several years, or even of several decades (Garlick, 1978; Yorke and Krügel, 1977). The conceiving star is not visible in the optical range due to strong absorption in the surrounding dust and gas envelope. The characteristic features of the activity manifestations of such stars are compact or supercompact H II regions and infrared and maser emission. It seems that variability of H_2O maser emission may serve as an indicator of the star's state (protostar) in early stages of its evolution.

The first regular observations of H_2O maseres associated with regions of star formation showed that the maser activity has a cyclic character, i.e. there occur alternating periods of active and quiet states of H_2O masers (Lekht *et al.*, 1983). Observations performed during longer periods confirm this statement and allow us to carry out more profound qualitative and quantitative analysis (Lekht, 1994; Lekht *et al.*, 1995a, 1995b).

Since 1980, regular observations of a large number of H_2O maser sources are being carried out at the radio telescope RT-22 in Pushchino. At present, the data from sources NGC2071, S252A, W31A, G43.8–0.1, ON1, W75N, W75S, S128 and S140 are being reduced. An important parameter which characterizes the state of

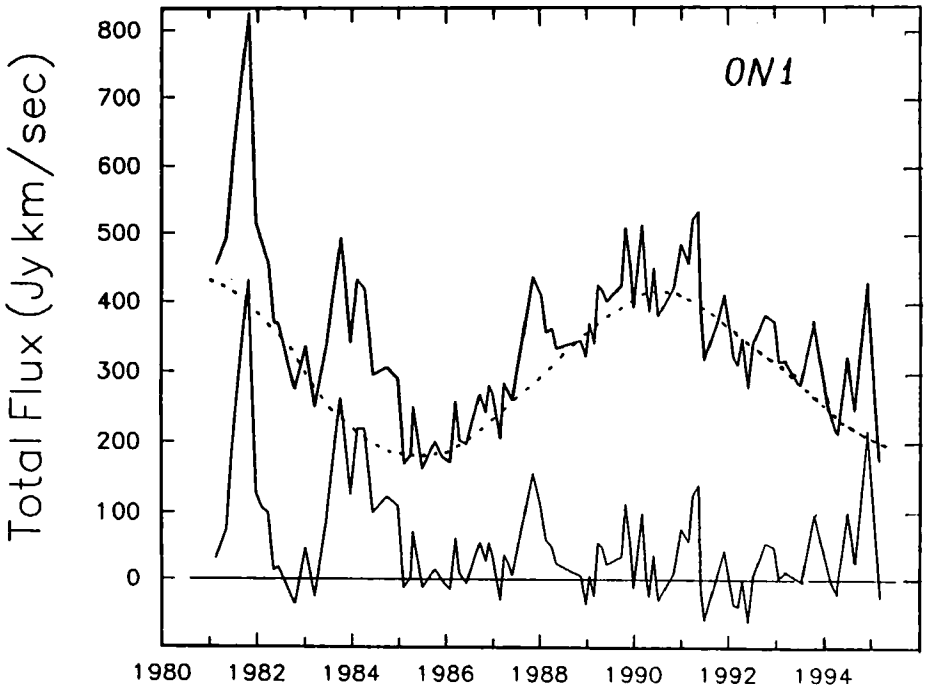

Figure 1 Time variations of the total flux of the maser emission in the source ON1. The dotted line shows the long-term component and the thin solid line represents the burst like one.

an H_2O maser is the total flux. For most sources the time variations of the total flux have a rather complicated character. For some cases the curve of variability of the total flux can be represented as a superposition of two components: a long-term component and a burst-like one.

The long-term component shows that for many sources the maser activity has a cyclic character with a period of 4–10 years. The ratio of the total flux in maximum to that in minimum is different for different sources and it varies from about two for ON1 up to about a hundred for W75S. According to our observations, one can find three types of the variability:

1. A sinusoidal form of variability – ON1 (Lekht *et al.*, 1995a).
2. Periodic with variable amplitude – W31A, S128, and possibly G43.8–0.1 and NGC2071 (Lekht *et al.*, 1995b, 1995c; Berulis *et al.*, 1995).
3. Variability of the total flux with transitions from active to quiet states of the masers – W75N, W75S and S252A (Lekht, 1994; Lekht *et al.*, 1995b).

For the sources of the third group the long-term component has a complicated form of variability. It is not excluded that in some cases (for example, W75S) a superposition of two periodic processes with different periods may occur. However,

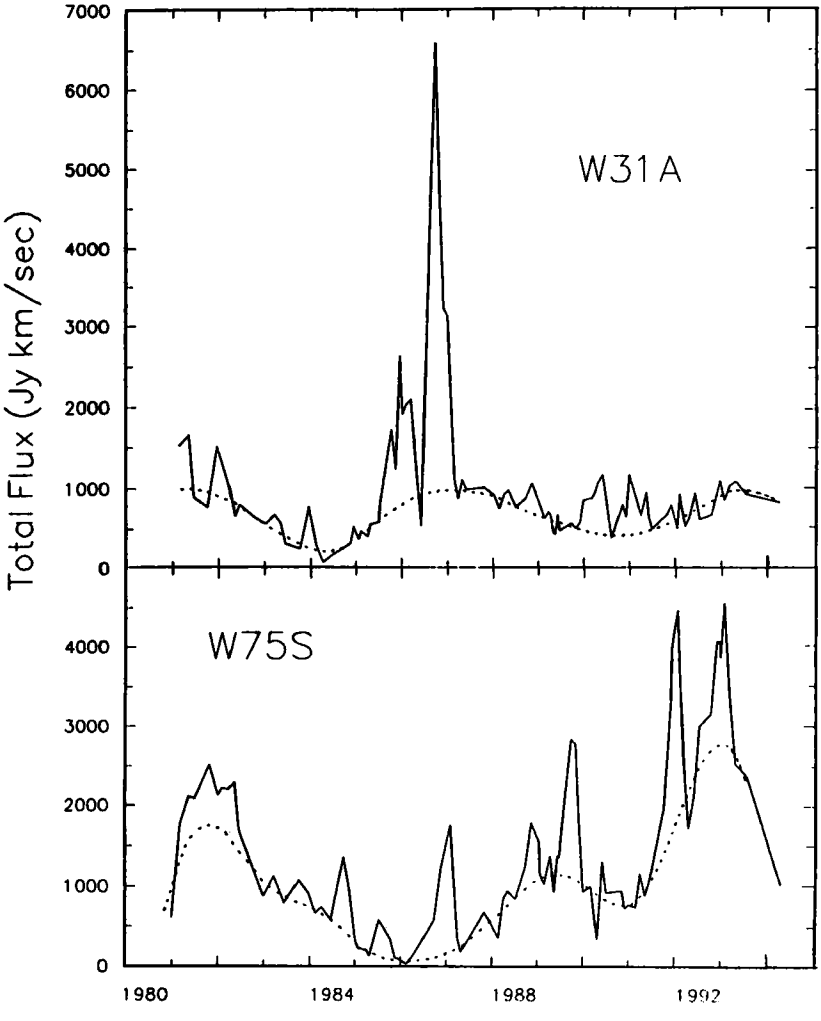

Figure 2 Time variations of the total flux of the maser emission in the sources W31A and W75S. The dotted line shows the long-term component.

in order to clarify this possibility one needs observations covering a period of more than 20 years.

Time variations of the total flux for the sources which represent the three groups are given in Figures 1 and 2.

The burst activity of masers was manifested in different ways. We observed both bursts in some details of the spectrum and bursts of whole groups of details. The former bursts have, apparently, the local character and can be related to variations in pumping conditions in maser condensations or with variations in geometry of the maser particularly, with the increase of the path of the signal amplification

(see Liljeström *et al.*, 1989). The bursts of the group of details have a global character with respect to the maser, i.e. they have the same cause for all the details (condensations). The bursts of the global form were observed to be relatively regular with the time intervals $\sim$ 2–4.5 years. The most intensive bursts were observed to be more seldom. During our observations (1980–1994) only one strong burst was observed in W31A, three such bursts in G43.8–0.1, and five in W75S, W75N and NGC2071.

Only in the source ON1 the bursts of some separate components had comparatively small intensity and occured at very irregular moments. The sinusoidal form of the long-term variable component with a small ratio of total fluxes in minimum and maximum of the maser activity and the existence of weak irregular bursts may be due to the fact that the central star in ON1 does not have large brightness variations. It seems that at present stage of evolution the process of star formation in ON1 has a comparatively stationary character.

So, the variations of the long-term component of the total flux and the global character of bursts in the H_2O maser sources are related most probably to the variability of a stellar wind from the central star. This variability can be a consequence of an unstable state of the star during initial stages of its formation. This unstable state can be due to non-stationary accretion of matter. The characteristic times of variability of H_2O maser emission (cyclic activity of masers) are in a good agreement with theoretical estimates.

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