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Twenty-six-year monitoring of water masers

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Abstract. Since 1980 variability of a sample of H_2O maser sources has been monitored on the 22-metre radio telescope in Pushchino, Russia. The interval between successive observational sessions is 1–2 months. The sample includes 125 maser sources in star-forming regions (SFR) and late-type variable stars. Twenty-six-year time series of H_2O line profiles have detected flares and velocity drift of spectral features. Very fast variations in the H_2O maser flux ($\Delta t \lesssim 1$ hour) have been detected in several SFR sources, in particular, W33B. Variations of circumstellar H_2O masers in late-type stars correlate with visual light curves with a time lag of 0.3–0.4P (P is the star's period). Exceptionally strong H_2O maser flares were recorded in SFR sources (Sgr B2 and others) and in the stars W Hya, R Cas and U Ori. Models for H_2O maser variability are reviewed. For stellar masers shock-wave excitation of H_2O line variability is discussed.

Keywords. molecular processes, radio lines: ISM, radio lines: stars, masers, surveys, stars: formation, stars: AGB and post-AGB, circumstellar matter, shock waves

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Since 1980 our team has been monitoring cosmic maser sources radiating in the 6_{16}–5_{23} rotational line of the water vapour molecule at $\lambda = 1.35$ cm (Lekht *et al.* 1982; Berulis *et al.* 1983). The observations are carried out on the 22-metre radio telescope of the Pushchino Radio Astronomy Observatory. The sensitivity is about 10 Jy, the velocity resolution is 0.081 km/s. The interval between successive observational sessions is 1–2 months.

The sample includes 125 maser sources of which 65 are in star-forming regions (Ori A, W75N, G43.8−0.1, NGC 2071 etc.) and the rest are in circumstellar envelopes of late-type variable stars (U Ori, RS Vir, RT Vir, U Her, VY CMa, VX Sgr etc.). For most sources H_2O line profiles have been measured for more than 200 epochs between 1980 and 2006.

For masers in star-forming regions the long time series have revealed some previously unknown regularities in the variations of the H_2O line profiles (flares and velocity drift of individual spectral features). Figure 1 (*left*) presents examples of strong maser flares observed in the SFR source Sgr B2 (Ramírez Hernández *et al.* 2005). In some SFR sources (S255, NGC 7538) models of rotating proto-planetary discs and/or bipolar outflows are applicable (Lekht *et al.* 2004). Velocity drifts of maser features may reflect orbital motion of proto-planetary condensations. Dedicated observations allowed us to detect very fast variations in the maser flux of some sources (in particular, Sgr B2 and W33B) on a timescale shorter than 1 hour (Ramírez Hernández *et al.* 2005; Samodurov *et al.* 2007).

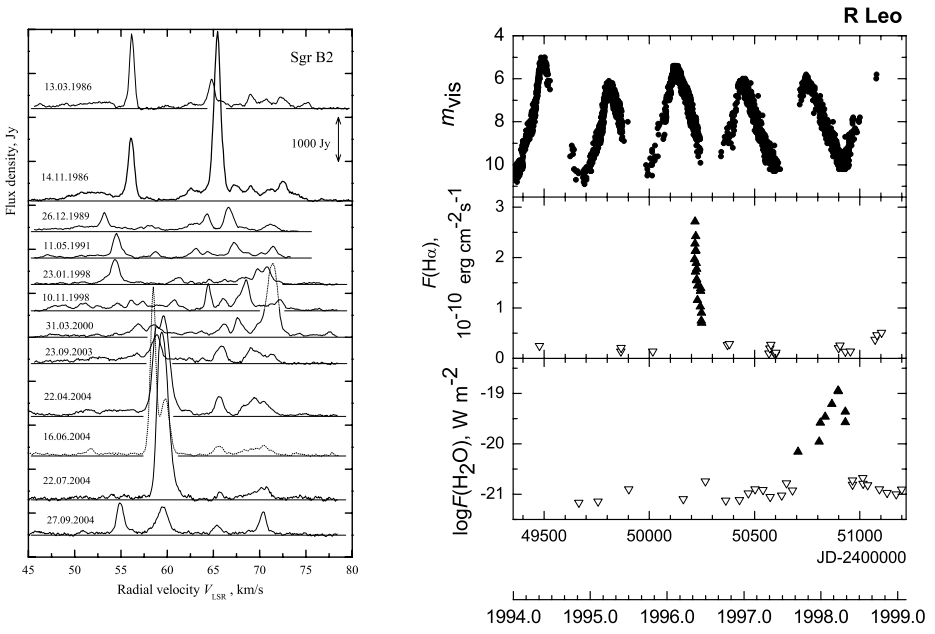

Figure 1. Flares of the H_2O maser sources Sgr B2 and R Leo.

Variations of circumstellar H_2O masers in late-type stars (U Ori, S CrB, U Her, RS Vir and others) correlate with the visual light curves with a time lag of 0.3–0.4P (P is the star's period). Exceptionally strong H_2O maser flares were noted in W Hya, R Cas and U Ori. Parallel optical spectroscopy of the stars has been carried out since 1994. Flares of the Hα line emission recorded in R Leo, U Aur, R Cas and R LMi were followed 1.5–2 years later by corresponding flares of the H_2O masers. Figure 1 (*right*) shows an example of such a flare in the Mira-type star R Leo (Esipov *et al.* 1999). These phenomena are interpreted as a consequence of propagation of a shock wave driven by stellar pulsation. A strong shock propagating in the inner layers of a circumstellar envelope produces optical emission lines; further out, as the shock becomes weaker, it excites the H_2O maser.

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