

Magnetic Fields in 7 Young Stellar Objects Observed with Nançay Radio Telescope

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Abstract. Magnetic fields (MF) can play an essential role in the evolution of the interstellar medium - especially at the early evolutionary stages. Small scale research related to the interaction of MF and pre-stellar condensations are unresolved issues. In quantitative terms, submissions about forming a full picture of gas-dust fragments evolution are far from complete, considering delay of their collapse caused by MF and the reverse effect of self-gravitating objects on the transformation of force lines and changing the values of local strength. The role of these interrelated processes is very important in the estimation of time of evolution of protostellar structures. In contrast to OH, in methanol molecule (most investigating at the moment) there is no unpaired electron, and the Zeeman splitting of the energy levels in CH₃OH regards only the levels caused by the nuclear spin. Therefore, Zeeman spectrum in methanol is certainly not going to be as effective as in OH. However, since many methanol masers - Class I (MMI - formed at the earliest stage of the evolution of gas and dust condensations) and Class II (MMII - the area around very young stars and protoplanetary disks) - are associated with OH masers, then from spectra of OH masers the parameters of MF can be estimated, at least, near different methanol masers classes, i.e. in condensations which are at different evolutionary stages. This report presents the results of polarization observations 7 OH maser sources at the NRT (France). The main goal is comparing similarities and differences in MF strength and orientation in these masers, which essentially different according to the type of methanol masers associated with them, i.e. the evolutionary type.

Keywords. Masers, magnetic fields, ISM: evolution

We carried out observations 7 OH maser sources in October 2003 at the Nançay Radio Telescope (NRT), France. The telescope and receiving equipment technical specifications and calibration standard methods you can find in Szymczak *et al.* (1997), Slysh *et al.* (2010).

Observations were made in the two main lines of OH - at 1665 and 1667 MHz. These observations were done in the circular polarization using a phase shifter. All four Stokes parameters in each autocorrelator channel can be obtained by combining polarization modes.

Gaussian parameters of OH spectra details are obtained and estimates of polarization parameters (the degree of circular polarization m_C , the linearly polarized flux density p , the degree of linear polarization m_L) were made. The calculated values obtained by the well-known formula, see Szymczak (2009).

Estimates of the magnetic field strength B were obtained according to the Zeeman splitting of the OH lines and the approximation the Stokes parameter V by the derivative from Stokes parameter I . We used standard formula, that can be found in Elitzur (1998), Crutcher (1999). It was shown that the value B fluctuates for different sources in the range of ≤ 0.5 mG to 1.4 mG.

The analysis of the association the OH masers with methanol emission was conducted: it was shown, that the magnetic field in OH masers associated with MMI can be

determined more reliable, than in OH masers associated with MMII and has higher values. It was shown, that investigated areas may be linked structures as small clouds IRDC or the typical protoplanetary disks. Probably, one can consider, that the magnetic field obtained from the spectrum of the OH maser characterizes the magnetic field in the condensation forming a methanol maser - within the limits of errors in determining the distances between OH masers and MMII in these sources.

In the investigated sources areas have been allocated with the centers on the coordinates of observed OH maser condensation clusters. The question of a possible association of OH maser clusters and the closest MMI and MMII clusters was worked out in details. It was shown, that these associations are real, i.e. magnetic field acting within the OH clusters can be extended to the methanol maser groups.

Values of volume density of molecular hydrogen in OH condensations, its column density and the column OH density, the ratio of the mass to the magnetic flux in size of the investigated area between OH masers and methanol masers, the ratio of thermal to magnetic pressures and the virial ratios of the gravitational, kinetic, and magnetic energy were obtained.

It was shown, that in the majority of sources the ratio of the mass to the magnetic flux exceeds the critical value. On the other hand, it was shown, that the ratio of thermal to magnetic pressures in all cases <1 in hotter areas and $\ll 1$ in cold, i.e. clouds can be found in dominant magnetic mode. This conflict is associated with possible large errors as in determining the values of the magnetic field strength (in particular, the angle θ , characterizes its orientation) as well as in possible overvaluation of the distance to the source increases the size of the studied areas.

We obtained estimates of the gravitational collapse time in the considered sources 0.06 to 0.13×10^6 years which is less or comparable to typical lifetime of the star forming region 10^5 years.

This analysis shows that the question of the spatial overlap or not overlap of OH, I or MMII masers groups is open for today and it is fundamental for the assessment of the possibility of using the magnetic fields data obtained from the OH masers spectra for the solution problem of the magnetic fields influence on the process of stability or instability of methanol maser condensations, which is particularly important for the progress in the understanding of methanol maser models, especially Class I.

Online figures for all sources are available: <http://www.asc.rssi.ru/OB/NP.pdf>

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