OBSERVABILITY OF THE MAGNETIC FIELD IN MOLECULAR CLOUDS

N. BEL and B. LEROY
Observatoire de Paris-Meudon
92195 Meudon Cedex
France

ABSTRACT. We have done detailed calculations of the Zeeman effect in the dozen diatomic molecules identified in interstellar clouds.

The magnetic field has become recognised as an unavoidable ingredient to be taken into account in the evolution of interstellar clouds.

The Zeeman splittings have been obtained from standard procedures of quantum mechanics. Only CN and SO exhibit an effect comparable to that in OH. The magnitude of this effect is best appreciated in terms of the frequency separation, $\Delta\nu$(Hz), of the σ-components for a given magnetic field strength, B (μG). For instance, for the transition NJF = 1,3/2,3/2 → 0,1/2,1/2 in CN, $\Delta\nu$ = 2.2 Hz/μG, and for the transition NJ = 2,1 → 1,2 in SO, $\Delta\nu$ = 1.7 Hz/μG. (Recall that for the 1665 MHz line of OH, $\Delta\nu$ = 3.27 Hz/μG.)

For the other observed diatomic molecules, CO, CS, SiO and SiS exhibit separations of the order of a few 10^{-4} Hz/μG, and the corresponding values for NO, NS and CH are still smaller.

To be detectable the signal should be greater than the minimum detectable temperature ΔT_{rms} of the telescope which leads to a lower limit on the detectable magnetic field:

$$B_{min} \approx \Delta T_{rms}\ \Delta\nu_1 / \Delta\nu T_A^*.$$

For the 30-m antenna of IRAM

$$\Delta T_{rms} = 3 - 5 \text{ mK}$$

for a system temperature T_{sys} = 600 or 1000 K, according to whether the 230 or 115 GHz-receptor is used, a typical pre-detection bandwidth of 1 MHz and an observing time $\tau \approx 50$ h (which is of the order of the observation time for OH observations); then B_{min} reaches a few 100 μG.

This value is of the order of magnitude one could expect in moderately dense clouds, and well below the magnetic strength inferred near the Galactic Centre.

Let us note that the molecule O_2 exhibits a pronounced Zeeman effect, even stronger than that of OH. Unfortunately, these transitions are strongly absorbed in the atmosphere.

R. Beck et al. (eds.), Galactic and Intergalactic Magnetic Fields, 304.