MAGNETICALLY CONTROLLED GRAVITATIONAL INSTABILITIES IN THE TAURUS MOLECULAR COMPLEX

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The periodic structure we [1,2] have previously reported as puzzling in the velocity field and column density of 21 cm self-absorption in the Taurus Complex, can be explained naturally in terms of the gravitational collapse of the HI along the lines of force of the large-scale magnetic field of the region.

The principal observational findings are that:
(a) there is a large-scale magnetic field in the region oriented at position angle ~45°, with a superposed "S-shaped" modulation [3].
(b) the projected wavelength in the 21 cm velocity field is 16 pc, and the wavefront is perpendicular to the magnetic field.
(c) the underlying structure of the 21 cm column density appears to consist of three parallel filaments, spaced 11 pc apart, which are oriented perpendicular to the magnetic field direction.

In the scenario we envisage, the "S-shaped" modulation of the optical polarization alignment, and the modulation of the 21 cm velocity field, are attributed to transverse vibrations of the magnetic field lines, respectively parallel and perpendicular to the plane of the sky - i.e. an Alfvén wave mode with phase velocity $v_A = B/\sqrt{4\pi\rho}$. The filamentary structure in the column density is produced by the growth of a Jeans instability propagating along the field lines with phase velocity $v_J = \sqrt{c^2 - G\rho\lambda^2/\pi}$, where c is the turbulent sound speed, and λ is the corresponding wavelength.

Following the idea of Kleiner and Dickman [4], the instability originated in primordial matter which was largely atomic hydrogen, having a mean density of 20-200 protons cm^{-3} (calculated from $\lambda_A/\lambda_J = v_A/v_J = 16/11$, $B = 3-10\ \mu G$, $c = 1.0\ km\ s^{-1}$, and $\lambda = 16$ pc). Its growth, and subsequent chemical evolution, has led to the much larger density values presently detected in the central molecular filament of the Taurus Complex, while preserving the spacing between the filaments at a "fossil" Jeans wavelength.

References

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