Polarization Structure of Magnetically Supported Molecular Filaments

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Observations of thermal dust emissions with Herschel satellite have revealed that molecular clouds consist of many filaments [1]. That is, the molecular filaments are the building blocks of interstellar clouds. On the other hand, near IR interstellar polarization indicates the filaments are extending in the perpendicular direction to the interstellar magnetic field [2].

Equilibrium solutions of isothermal clouds, in which the gravity is balanced with the Lorentz force, thermal pressure and the external pressure, are obtained with a self-consistent field method [3]. Figure 1 shows two typical such solutions, where the left one has a low density-contrast between the center and the surface $\rho_c/\rho_s = 10$ while the right one has a higher contrast $\rho_c/\rho_s = 300$. Here, we studied polarization structures of the thermal dust emissions expected for the magnetized filaments [4].

The polarization of the thermal dust emissions comes from dusts which are aligned to the interstellar magnetic field. Expected polarization pattern is calculated for the equilibrium filaments observed from the line of sight specified with two angles $\theta$ and $\phi$ (see Fig. 2 left). We showed the models with $(\theta, \phi)=(80^\circ, 90^\circ)$ in Figure 2. The middle panel corresponds to a low-density filament of Fig. 1 (left). Low polarization degree comes from the configuration in which the line of sight is nearly parallel to the large-scale B-field. On the other hand, a high-density filament with $\rho_c/\rho_s = 300$ (right) shows a polarization pattern as if B-field were perpendicular to the filament. This may explain the fact that the perpendicular configuration is so commonly observed.

References


Figure 1: Isothermal filaments threaded by lateral magnetic fields, which were obtained under the assumption of mechanical equilibrium using a self-consistent field method [3]. These two models have the identical magnetic flux, isothermal sound speed and external pressure but different central density (left: $\rho_c = 10\rho_s$; right: $\rho_c = 300\rho_s$).

Figure 2: Left: relation between the filament and the observing line-of-sight. Expected polarization patterns of the low-density filament (middle), and the high-density filament (right). The polarization degree and its direction (electromagnetic wave B-vector) are shown by false-color and short bars, respectively.