9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Physical Properties of Molecular Cloud Cores Formed in Strongly Magnetized Molecular Filaments

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Star and planet are formed from the molecular cloud core which is a dense region of the molecular cloud. It is crucial to reveal the physical property of molecular cloud cores because it determines the properties of the star and planet system and their diversity. The angular momentum of molecular cloud cores plays a key role in the star formation process since it is an important parameter, for example, to determine whether a multiple system is formed or not resulting from the fragmentation of the molecular cloud core[1]. Recent observations show that the molecular cloud cores along the filamentary structure which is a dense elongated structure in the molecular cloud[2]. However, the evolution of the angular momentum of molecular cloud cores formed in magnetized molecular filaments is still unclear. We have investigated the effect of the magnetic field on the evolution on the angular momentum of cores. However, in our previous study, the range of the magnetic field strength is limited up to 10uG. Observations show that the strength of the magnetic field in the filaments are relatively strong and that some of the cores are marginally supercritical. These observations suggests that it is important to investigate the physical properties of cores formed in strongly magnetized molecular filaments.

In this study, we perform 3D magnetohydrodynamics simulations to reveal the effect of the strong magnetic field on the evolution of the angular momentum of molecular cloud cores formed through filament fragmentation. We implement a Godunov smoothed particle magnetohydrodynamic (GSPM) method[3] in the Framework for Developing Particle Simulator (FDPS) to parallelize the code.

Our results show that the initial angular momentum of the core with mass of one solar mass is transferred during their formation phase in the strong magnetic field case. If the initial magnetic field is weak, the rotation direction of the cores is perpendicular to the filament longitudinal axis due to the effect of the filament geometry. On the other hand, if the magnetic field is strong, the signature of perpendicular rotation becomes less clear due to the strong magnetic braking. We also investigate the rotation direction with respect to the local magnetic field direction. Our results show that most of the cores experience the alignment of the rotation direction with the magnetic field (Fig.1), but the distribution of the angle between the rotation direction and magnetic field follows random distribution. This is because the angular momentum vector continues to oscillate even after the alignment.

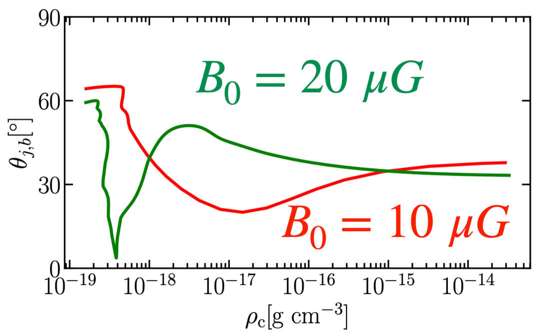

Fig1: Evolution the angle between the rotation direction and magnetic field of a core. The vertical axis is the angle between the rotation direction and magnetic field of a core. The horizontal axis is the maximum density of the core which corresponds to the time evolution. The red and green solid lines represent the weak and strong magnetic field cases.

Numerical computations were carried out on Cray XD2000 at the Center for Computational Astrophysics, National Astronomical Observatory of Japan. This work is supported by Grants-in-aid from the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) of Japan (18H05436). This work is also supported by JSPS KAKENHI grant No. 23K19073.

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