Self-gravitational Collapse of a Magnetized Cloud Core: High Resolution Simulations with Three-dimensional MHD Nested Grid

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We investigate self-gravitational collapse of magnetized molecular cloud cores and formation of the outflow. We employ nested grid in order to resolve fine structure of outflow generation, of which size is 1AU, and to follow the whole structure of the molecular cloud core, of which radius is 0.14 pc, simultaneously. The nested grid allows us to follow the evolution of the cloud core with the high dynamic range of 10^5–10^6 in the spatial resolution.

The nested grid consists of concentric hierarchical rectangular grid. Each grid has successively by a factor two different cell width. The n-th level grid has thus 2^{n-1} times higher spatial resolution than the coarsest grid. The maximum level of the grid is n = 13–15 in typical models. All the numerical fluxes are conserved at the interface between the coarse and fine grids in our code similarly to the standard adaptive mesh refinement (AMR). Not only the numerical fluxes of MHD equations but also those of the Poisson equation (gravity) are conserved. This ensures continuity of the gravitational field lines at the grid interfaces and that our solution satisfies the Gauss's theorem and Stokes' theorem.

We construct two models. In the first model, we focus on the fragmentation of the cloud core during the collapse. The cloud core collapses to fragment into two dense cores, which evolve to protobinary stars. The magnetic field transports the angular momenta of the cloud core and the fragments during the collapse. Each fragment has a circumstellar disk threaded by magnetic field and ejects outflow, which transports the spin angular momentum of the fragment efficiently. The criterion of the fragmentation is specified by the rotation speed of the cloud core and strength of the magnetic field. In the second model, we investigate effects of direction of magnetic field on generation of the outflow. When the magnetic field is parallel to the rotation axis of the cloud core, the cloud core collapses to form a dense core surrounded by circumstellar disk, and a strong outflow forms. On the other hand, the magnetic field is normal to the rotation axis, no outflow forms while magnetic breaking transports the angular momentum of the cloud core.