Pf-003 Room: C513 Time: June 28 14:55-15:10

Gravitational Collapse of Rotating Clouds and Condition for Disk Fragmentation

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Dynamical collapse of rotating molecular clouds due to the gravitational instability is investigated using three-dimensional numerical hydrodynamical calculations. The condition for disk fragmentation is derived by systematic numerical experiments for various initial density distributions, rotations, temperatures, and amplitudes of perturbation. We also show that we can predict the fragmentation condition by a semianalytic model that treate an axial ratio of an isodensity contour in the central region of clouds.

The fragmentation process during gravitational collapse of molecular clouds is one of important basic processes that has not been well understood yet. This problem is also important to understand the property of IMF (Initial Mass Function) and formation of binary stars.

As a first step we investigated the collapse of rotating isothermal clouds in detail. A semianalytic spheroid model and three-dimensional self-gravitating hydrodynamics are used to find out the criterion that predicts the outcome after the collapse of initially uniform-density rigid-rotating spheres. The geometrical flatness of the isodensity contour in the central region is shown to be a good indicator to predict whether the cloud fragments or not. The criteria derived by the three-dimensional calculations and the semianalytic model agree well in the alpha_0-beta_0 diagram, where alpha_0 and beta_0 are the ratio of the thermal and rotational energy to the gravitational energy, respectively. The warm clouds (alpha_0 > 0.5) converge to the runaway collapsing self-similar solutions without fragmentation before the central core formation. Dependence on the initial rotation parameter beta_0 is found to be small (Tsuribe & Inutsuka (1999a; ApJ, 523, L158, 1999b; ApJ, 526, 307)).

The effects of initial density central concentration, increase of temperature, and transition of equation of state to the fragmentation criteria are also investigated to discuss possibilities of hierarchical fragmentation.