論文内容の要旨

論文題目：Formation and Early Evolution of Cicumstellar Disks
(星周円盤の形成とその前期進化過程の研究)

氏名　塚本裕介

In this thesis, the formation and evolution of circumstellar disks is investigated from the prestellar cloud core stage using numerical simulations. To realize the long-term evolution of circumstellar disks with non-linear effects, I developed a smoothed particle hydrodynamics (SPH) simulation code that is parallelized with message passing interface (MPI). I investigate disk formation in two quite different environments: in a cloud core with (1) systematic rotation and (2) turbulence. In simple terms, the former corresponds to star formation in a less active star-forming region such as the Taurus star-forming region, while the latter corresponds to star formation in a highly active star-forming region, such as the NGC 1333 star-forming region. In each environment, I simulate disk formation with various cloud parameters and investigate the long-term evolution of circumstellar disks.

In a cloud core with systematic rotation, a circumstellar disk gradually grows after protostar formation. The initial ratios of thermal and rotational energy to the gravitational energy of the cloud core determine the final fate of the circumstellar disk. The disk evolution in such cloud cores is classified into four different evolution modes: (i) the massive disk, (ii) early fragmentation, (iii) late fragmentation, and (iv) protostar dominant modes. In the ”massive disk mode”, to which the majority of models belong, the circumstellar disk is more massive than the protostar for $> 10^4$ years after protostar formation, and no fragmentation occurs in the circumstellar disk. The collapsing cloud core shows fragmentation *before* protostar formation in the ”early fragmentation mode”. The circumstellar disk shows fragmentation *after* protostar formation in the ”late fragmentation mode”, in which the secondary star substantially gains its mass from the circumstellar disk after fragmentation in a short time and has a mass comparable to the primary star. On the other hand, the protostar rapidly increases its mass and exceeds the circumstellar disk’s mass in the ”protostar dominant mode”.

On the other hand, the disk evolution in a turbulent cloud core is substantially different from that in a non-turbulent cloud core. In a turbulent cloud core, the protostar forms in the filament, and the remaining filament twists around the protostar and becomes the circumstellar disk. In addition, the disk orientation dynamically changes with time during the main accretion phase, because the local velocity field around the protostar determines it. The time variation of the disk

orientation can explain the observational inconsistency between the disk orientation and outflow direction. Fragmentation frequently occurs and a wide binary system appears in a supersonically turbulent cloud core. In such a wide binary system, disks are mutually misaligned, and inclined against the binary orbital plane at least during the main accretion phase. Although the disks can be gradually aligned with each other because of the tidal interaction between protostars, it is expected that the disk's orientations are not completely aligned within their life-time. This misalignment can explain recent observations of disk misalignment and misaligned protostellar outflow.