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Formation of satellite systems in a circum-planetary disk

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We have investigated the origin of difference between the Jovian and Saturnian satellite systems by semi-analytically simulating growth and orbital migration of proto-satellites in an accreting proto-satellite disk, with the ideas of 1) different termination timescales of gas infall onto the proto -satellite disk and 2) different evolution of a cavity in the disk, between the Jovian and Saturnian systems. The Jovian satellite system mainly consists of four Galilean satellites those have similar masses and are trapped in mutual mean motion resonances except Callisto. On the other hand, the Saturnian satellite system has only one big icy body, Titan. We have simulated accretion of satellites, their orbital migration, and resonant trapping, taking into different decay timescales in the Jovian and Saturnian disks suggested by a gas giant formation model. Evolution of an inner cavity in the disk is also considered, based on observations of T Tauri stars. We show that in the case of the Jovian system, four to five similar-mass satellites are likely to remain trapped in mean motion resonances, the configuration of which is formed by type-I migration, temporal stopping of the migration near the disk inner edge, and quick truncation of gas infall by gap opening in the Solar nebula. The Saturnian system tends to end up with one dominant body in the outer regions caused by the slower decay of gas infall associated with global depletion of the Solar nebula. The compositional zoning of the predicted Jovian and Saturnian systems are consistent with the observed satellite systems.

Keywords: gas giant planet, satellite, satellite formation, circum-planetary disk