Electrostatic Barrier against Dust Coagulation in Protoplanetary Disks

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Coagulation of submicron-sized dust grains is the initial step of dust evolution in protoplanetary disks. These grains are expected to carry nonzero negative charges in the weakly ionized disks, but its effect on their collisional growth has not been fully understood so far. In this study, we investigate how the charging affects dust coagulation properly taking into account the charging mechanism in a weakly ionized gas. We find that protoplanetary disk involves a "frozen zone" where dust coagulation significantly slows down at its very early stage. For low-turbulence disks, the frozen zone covers the major part of the disks at a few to 100 AU from the central star. It is shown that the electrostatic barrier inhibits dust growth on timescales shorter than 10^6 yr. This might explain "slow" ($\sim 10^6$ yr) dust evolution suggested by infrared observation of T Tauri stars and by radioactive dating of chondrites.

Keywords: Dust; Charging; Protoplanetary disks.

References

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