# Electric charging of dust aggregates and its effect on dust coagulation in protoplanetary disks

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Mutual sticking of dust aggregates is the first step toward planetesimal formation in protoplanetary disks. In spite that the electric charging of dust particles is well recognized in some contexts, it has been largely ignored in the current modeling of dust coagulation.

In this study, we present a general analysis of the dust charge state in protoplanetary disks, and then demonstrate how the electric charging could dramatically change the currently accepted scenario of dust coagulation. First, we describe a new semi-analytical method to calculate the dust charge state and gas ionization state self-consistently. This method is far more efficient than previous numerical methods, and provides a general and clear description of the charge state of gas-dust mixture. Second, we apply this analysis to compute the collisional cross section of growing aggregates taking their charging into account. As an illustrative example, we focus on early evolutionary stages where the dust has been thought to experience ballistic cluster-cluster aggregation (BCCA). We find that, for a wide range of model parameters, the BCCA growth is strongly inhibited by the electric repulsion between colliding aggregates and eventually “freezes out”. Strong disk turbulence would help the aggregates to overcome this growth barrier, but it would cause the collisional fragmentation in later growth stages. These facts suggest that the combination of electric repulsion and collisional fragmentation would impose a serious limitation on dust growth in protoplanetary disks. We propose a possible scenario of dust evolution after the freeze-out.