

## Dynamics of Charged, Polarizable Particles in Extreme Atmospheric Environments

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### Abstract:

Volcanic ash plumes and the Venusian atmosphere are examples of extreme atmospheric environments characterized by scorching temperatures and high densities of charged, polarizable particles. This study investigates the influence of polarization on particle interactions in these environments, employing dynamic simulations built upon a rigorous classical electrostatic formalism.<sup>[1,2]</sup> Our findings highlight the pivotal role of polarization in driving electrostatic aggregation under extreme conditions, particularly through like-charge attraction at small separations, which would otherwise be neglected under conventional models. By considering complex polarization effects, we reveal significant deviations from traditional Coulomb and hard-sphere models, including the increase in collision efficiency and collisional cross section by up to 25% as well as reduction in the velocity critical for aggregation by up to 30%. Notably, critical values obtained from dynamic simulations are shown to fall within 5% of their corresponding theoretical predictions determined using a statistical approach.<sup>[3]</sup> These insights have wide-ranging implications for modelling charged particle dynamics beyond extreme environments to broader industrial, atmospheric and astrophysical contexts.

[1] - M. Hassan, *et al.* Manipulating Interactions between Dielectric Particles with Electric Fields: A General Electrostatic Many-Body Framework, *J. Chem Theory Comput.* (2022), **18**, 6281-6296

[2] - E. Lindgren, *et al.* Dynamic simulations of many-body electrostatic self-assembly. *Philos. Transactions Royal Soc. A: Math. Phys. Eng. Sci.* (2018), **376**, 20170143

[3] - J Baptiste, *et al.* The influence of surface charge on the coalescence of ice and dust particles in the mesosphere and lower thermosphere. *Atmospheric Chem. Phys.* (2021), **21**, 8735–8745

Keywords: Dynamic Simulations | Polarization | Electrostatics | Particle Nucleation | Atmospheric Chemistry | Modelling

Category (topic): Fundamentals

Preference: Poster

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