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Design of new binary interaction classes in complex plasmas

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Laboratory complex plasmas are low-pressure non-equilibrium weakly ionized gas discharge plasmas containing charged microparticles ("dust"). Complex plasmas can be used as model systems to study crystallization and melting dynamics, phonons, solitons, supersonic dislocations in crystals, and other phenomena in condensed matter physics. An appealing feature of complex plasmas is the virtual absence of damping, which makes it possible to obtain full dynamical information at all relevant time scales. However, interparticle interactions in 3D complex plasmas are generally repulsive, whereas a number of fundamental generic processes, such as the liquid-vapor phase transition and the related critical phenomena, require attractive forces. To obtain and design attractive interactions in complex plasmas is a challenging problem.

We propose a method to obtain and design attractive interactions in complex plasmas by applying external ac electric fields of various polarizations. The physical idea of the method is that the applied field induces ion flow which distorts the Debye spheres of the compensating plasma charges surrounding microparticles and thus changes the interparticle interactions. To investigate the resulting interactions, we use a self-consistent kinetic description for ions with the Bhatnagar-Gross-Krook (BGK) ion-neutral collision integral. The analysis shows a variety of interaction classes including positive and negative dipolar interactions, triaxially anisotropic interactions, and spherically symmetric interactions of molecular type (i.e., consisting of a repulsion at short distances and an attraction at larger distances) [1].

This will make it possible to extend the approach of linear polarization of recent experiments onboard the International Space Station [2]. In particular, by using spherical polarization which corresponds to an interaction of the molecular type, it may be possible to use 3D complex plasmas as a realistic model system to study the atomistic dynamics of fluids, including the liquid-vapor phase transition and the behavior near the critical point.

References

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