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Using Coupled Dust Motion to Analyze Plasma-Dust Interactions

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Electric fields within a plasma cause positive ions to have a directed flow. The trajectories of the flowing ions are deflected by negatively charged dust grains immersed in the plasma, resulting in an ion wakefield downstream from the dust particles. The positive space-charge region not only modifies the interaction between the charged grains but also contributes to the stability of ordered particle structures. In earth-based laboratory experiments, the electric field in the sheath of a plasma is used to levitate dust grains. Since the ion flow is in the direction of gravity, the weak ion wakefield force is usually masked by the force of gravity. The PK-4 experiment on board the International Space Station removes this complication allowing the underlying physics behind self-ordering of interacting complex plasma dust particles to be investigated. In particular, we are interested in the plasma conditions which result in the formation of ordered field-aligned dust chains.

Here we report results of coupled numerical models of the plasma discharge, ion wakefield and particle interactions in the PK-4 environment. An axisymmetric PIC/MCC and hybrid discharge simulation is used to model the discharge conditions in the PK-4. The local plasma parameters determined by this model are then used as boundary conditions for the N-body code DRIAD (Dynamic Reactions of Ions And Dust) which models the dynamics of the ions and the dust on their individual time scales. The ion dynamics are influenced by the time-varying electric field within the DC discharge and interactions with the charged dust grains. Charging of the grains and the modified grain-grain interactions are self-consistently derived from the ion-dust interactions. The simulation results will be compared against video data form the PK-4 experiments

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