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Dust charging in the dense Enceladus torus

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The key parameter of the dust-plasma interactions is the charge carried by a dust particle. The grain electrostatic potential is usually calculated from the so called orbit-motion limited (OML) model [1]. It is valid for a single particle immersed into collisionless plasmas with Maxwellian electron and ion distributions. Apparently, such a parameter regime cannot be directly applied to the conditions relevant for the Enceladus dense neutral torus and plume, where the plasma is multispecies and multistreaming, the dust density is high, sometimes even exceeding the plasma number density. We have examined several new factors which can significantly affect the grain charging in the dust loaded plasma of the Enceladus torus and in the plume region and which, to our knowledge, have not been investigated up to now for such plasma environments. These include: (a) influence of the multispecies plasma composition, namely the presence of two electron populations with electron temperatures ranging from a few eV up to a hundred eV [2], a few ion species (e.g. corotating water group ions, and protons, characterized by different kinetic temperatures), as well as cold nonthermalized new-born water group ions which move with Kepler velocity [3]; (b) effect of the ion-neutral collisions on the dust charging in the dense Enceladus torus and in the plume; (c) effect of high dust density, when a grain cannot be considered as an isolated particle any more (especially relevant for the plume region, where the average negative dust charge density according to Cassini measurements is of the order or even exceeds the plasma number density [4,5]). It turns out that in this case, the electrostatic potential and respective dust charge cannot be deduced from the initial OML formalism and there is a need to incorporate the effect of dust density into plasma fluxes flowing to the grain surface to calculate the grain equilibrium charge; (e) since the dust in the planetary rings comes in a wide spectrum of sizes from macromolecules to the boulders of a few m in sizes, it becomes important to examine the effect of dust size distribution on the equilibrium particle potential.

The obtained results might be of importance for understanding the main physical processes occurring in the planetary rings including the problem of dust transport as well as for interpretations of Cassini plasma measurements in Saturn's rings.

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