N86-23524

THE ELECTROSTATICS OF A DUSTY PLASMA. E. C. Whipple and D. A. Mendis, University of California, San Diego, T. G. Northrop, Goddard Space Flight Center. We have derived the potential distribution in a plasma containing dust grains where the Debye length can be larger or smaller than the average intergrain spacing. We treat three models for the grain-plasma system, with the assumption that the system of dust and plasma is charge-neutral: a permeable grain model, an impermeable grain model, and a capacitor model that does not require the nearest neighbor approximation of the other two models. We use a gauge-invariant form of Poisson's equation which is linearized about the average potential in the system. The charging currents to a grain are functions of the difference between the grain potential and this average potential. We obtain expressions for the equilibrium potential of the grain and for the gauge-invariant capacitance between the grain and the plasma. The charge on a grain is determined by the product of this capacitance and the grain-plasma potential difference.

The three models give similar but not identical results. The results depend primarily on the parameter $Z = 4\pi\lambda^2 NC$, where λ is the Debye length, N is the grain concentration, and C is the grain to plasma capacitance. When $Z \gg 1$, the number of charges on a grain that is only charged by plasma currents is given by $(-Q/e) \cong [(\mu-1)/(\mu+1)][(\bar{n}_i+\bar{n}_e)/N]$ where μ is the square-root of the ion to electron mass ratio, and $\bar{n}_i$ and $\bar{n}_e$ are the average ion and electron densities. The charge on a grain in such regions is severely decreased from its free space value. The charge reduction occurs because the plasma electrons are depleted so that the grain does not need to be as negatively charged to equalize the ion and electron fluxes to its surface, despite the increased grain to plasma capacitance.