Electrostatic Charge on Insulating Dust Grains in a Plasma

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The electrostatic charge state of small insulating solid dust grains in a low density plasma is studied. A cubical shape represented by 16 elements on each face is used to give the grain model corners and edges. The grain model is electrically insulating, smaller than the Debye length, λ_d, and is allowed to have secondary electron emission and a drift velocity with respect to the plasma. Secondary electrons exit the grain surface with a cos θ distribution. The Maxwell velocity distribution is chosen to represent the plasma environment. Electrons or ions, which are treated as test particles, are chosen randomly from the plasma. Particle trajectories are computed numerically via leapfrog until they either strike the grain or return to the plasma. Impacting particles deposit their charge onto one of the 16 segments on a face of the cube. Escaping secondary electrons remove their charge from the surface. The simulation continues until an equilibrium condition is reached where the ion flux equals the electron flux. The final potential averaged over the grain surface is found consistent with spherically symmetric, analytic models. A negative potential is found for low yield grains and a positive potential is found for high yield grains. The resulting equilibrium grain charge is distributed over the surface so that the corners and edges have the largest charge density. This charge distribution is approximately consistent with an equipotential surface. Secondary electron emission causes corners and edges to have slightly higher potential than the rest of the grain. When secondary electron emission is important and the average grain potential is close to zero, different regions of the grain may approach different potentials. No dependence of the final charge state upon initial charge state is found. A grain drift velocity with respect to the plasma causes the grain to have a dipole moment but does not change the monopole moment of the grain greatly. This is true whether or not secondary electron emission is important. This work is the first to approach the problem of grain charging using a non-spherical insulating grain and three dimensional secondary electron emission properties.