Charging of interstellar dust grains in the non-equilibrium inner heliosheath plasma

P.C. Frisch[1], G. Livadiotis[2], K. Ogasawara[2], J.D. Slavin[3], D.J. McComas[4], H.O. Funsten[5]

[1]University of Chicago, IL, USA

[2]SWRI, TX, USA

[3]Harvard-Smithsonian CfA, MA, USA

[4]Princeton University, NJ, USA

[5]LANL, NM, USA

Interstellar dust grains flow into the heliosphere together with interstellar gas. The heliosheath plasma provides a barrier to the smallest charged grains, while larger grains with larger gyroradii penetrate to the inner heliosphere. Interstellar Boundary Explorer (IBEX) observations of Energetic Neutral Atoms (ENAs) trace the thermodynamics of the plasma where ENAs are born via charge-exchange and where many interstellar dust grains are deflected away from the inflowing stream. Most (75 percent) of the heliosheath plasma can be described with a stationary state kappa-distribution that represents a composite of a thermal core and a high-energy non-thermal tail (Livadiotis et al. 2011). The thermodynamic properties of the stationary non-equilibrium plasma, temperature, kappa-index, pressure and densities, provide the information needed for grain charging currents specific to the heliosheath regions. Ulysses tracked the dust at several AU for 16 years and found a deficit of submicron-sized grains compared with the canonical interstellar grain populations (Krueger et al. 2015). Previous simulations of the grain trajectories through the heliosphere have utilized Maxwellian plasma temperatures, and shown that grain charging in the heliosheath regions yields high charge-to-mass ratios that impede submicron grain propagation through heliosheath plasma. Grain-charging calculations are made using a charging-code (Weingartner and Draine 2001) that includes charging by grain interactions with protons, electrons, as well as the photo-ejection of electrons. Electron currents are expected to play a dominant role in grain charging in the heliosheath for most temperature regimes. However, given the absence of benchmark data on heliosheath electrons there is no consensus viewpoint about the electron thermodynamic state for this region. Consequently electron population thermal properties are generally also characterized using a kappa distribution. We assume that the same thermodynamic parameters characterize both the proton and electron heliosheath populations and perform grain charging calculations for the heliosheath regions based on the thermodynamic properties described by the kappa-distribution derived from IBEX ENA data. The balance between electron and proton currents on the grains, including photoionization, then provides the equilibrium grain charges. Grain gyroradii calculated based on these charging currents differentiate between interstellar grains able to penetrate the heliosphere, versus those that are excluded.

[l] Livadiotis et al., Ap. J. **734**, 1 (2011).

[2] Krueger et al., Ap. J. **812**, 139 (2015).

[3] Weingartner and Draine, .Ap. J. S. S. **.134**, .263 (.200).