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Numerical simulations of spinning, insulating objects being charged by plasma in sunlight

W.J. Miloch (1,2) and S.V. Vladimirov (2)

(1) Institute of Theoretical Astrophysics, University of Oslo, N-0315 Oslo, Norway (wojciecm@astro.uio.no), (2) School of Physics, The University of Sydney, NSW 2006, Australia (S.Vladimirov@physics.usyd.edu.au)

We study charging of spinning insulating objects by plasmas and photoemission due to directed photon flux. Photoemission due to solar radiation is important for the charging of objects in planetary atmospheres and space, and can lead to a positive total charge on the object [1]. For flowing plasmas, the wake structure behind such an object is substantially different from the wake behind negatively charged dust grains in plasma discharges or satellites in space [2,3]. Photoelectrons distort several spatial features of the wake in the plasma potential and density and can lead to strong polarization of the plasma, thus allowing for strong interactions between several of such objects [4]. While for conducting objects the charge is redistributed on the surface as to maintain the surface potential, the charge distribution on insulating objects is more intricate, and strong potential gradients are possible. Theoretical studies suggested that spinning of an insulating object in sunlight can redistribute the surface charge, and result in potential barriers for photoelectrons that will lead to the negative charge on the sunlit side of the object [5].

We study the charging of spinning insulating objects by means of numerical simulations. We consider flowing plasmas with different drift velocities, as well as different spin rates of an object. Photoemission is due to unidirectional photons, which can have different angles of incidence with respect to the plasma flow. The charge on the insulating, spinning object oscillates in time, and similarly the wakes in the plasma density and potential close to the object. The substantial rarefaction in the ion density for positively charged objects is being eroded in the vicinity of spinning insulators. This can lead to the closure of the wake and formation of the ion focusing region. The ion focusing is destroyed when the ion density rarefaction region reappears. Frequencies of the oscillations in charge and plasma potential and density depend on the spinning rate of the object. These oscillations can have important implications for interactions in a system comprising many such objects, as well as for satellite measurements of surrounding plasmas. Our results are compared with the results obtained without photoemission. The analysis is carried out in two spatial dimensions with a particle-in-cell code, where electrons and ions are treated as individual particles.

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