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Expansion fronts of solar wind ions and electrons at the wake boundary

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The solar wind interaction with an insulating, non-magnetized body such as the moon is characterized with the particle absorption and the surface charging. The solar wind particles that hit the moon are absorbed by the surface, creating a plasma cavity called the lunar wake behind the moon. At the boundary of the downstream wake, it has been often explained as "due to their greater thermal speed, the ambient electrons fill in the evacuated wake region faster than the ions, thereby creating an ambipolar electric field that retards the velocities of electrons and increases the velocities of the ions in a self-consistent way" (e.g., Farrell et al., GRL 1996).

According to the electromagnetic 2-dimensional particle-in-cell simulation with surface charging, it has been found that the ions enter the void faster than the electrons, producing positive excess of charge at the wake boundary in the vicinity of the obstacle (x = 1 Ro, where Ro is the radius of the obstacle). It is due to the negative electric potential of the nightside surface of the body, which retards the solar wind electrons coming to the wake boundary. Negative excess of charge is found in the central wake at farther downstream (x = 2 - 3 Ro). It should be noted that the simulation was for small object whose radius is several times as large as the Debye length, and the effect of the surface charging might be limited for a larger obstacle. The nightside surface charging is due to the electron thermal speed higher than the solar wind bulk speed, which is a basic nature of the solar wind plasma, and is caused mainly by higher energy component of the electrons, while the density profile is mainly constituted by the lower energy component that can be easily retarded by the surface charging.

Keywords: wake, electrons, expansion front, surface charging, PIC simulation, ambipolar electric field