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Effects of pickup ions on the solar wind near the lunar-like objects: 3D hybrid modeling

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Abstract

The hybrid kinetic model used here supports comprehensive simulation of the interaction between different spatial and energetic elements of the moon-solar wind-magnetosphere of the Earth system. This involves variable upstream magnetic field and solar wind plasma, including energetic ions, electrons, and neutral atoms. This capability is critical to improved interpretation of existing measurements for surface and atmospheric composition from previous missions and planning future missions. There is a set of MHD, kinetic, hybrid, drift kinetic, electrostatic and full kinetic modeling of the Lunar plasma environment that were performed in [1, 2, 3, 5, 6, 7, 8, 12, 13, 14]. However, observations show the existence of several species of the neutrals and pickup ions like Na, He etc., [4]. The solar wind parameters are chosen from ARTEMIS observations [14]. The hybrid kinetic model allows us to take into account the finite gyroradius effects of pickup ions and to estimate correctly the ions velocity distribution and the fluxes along the magnetic field. This is in opposition to the MHD simulation with Maxwellian velocity distributions for background and pickup ions. Photoionization, electron-impact ionization and charge exchange are included in all current models. We will also take into account collisions between ions and the surface of the moon and further sputtering of fragments from the surface of the moon. We will discuss the results of modeling, which includes separate species of pickup ions, (O_2^+, Na^+, and He^+) and their combinations. Modeling shows the asymmetric Mach cone, Fig. 1, pickup ion tails, Fig. 2, and presents another type of lunar-solar wind interaction. Our simulation may be important for the study of the interaction between the solar wind and very weak comets, and Pluto (see, e.g. [8, 9, 10, 11]).

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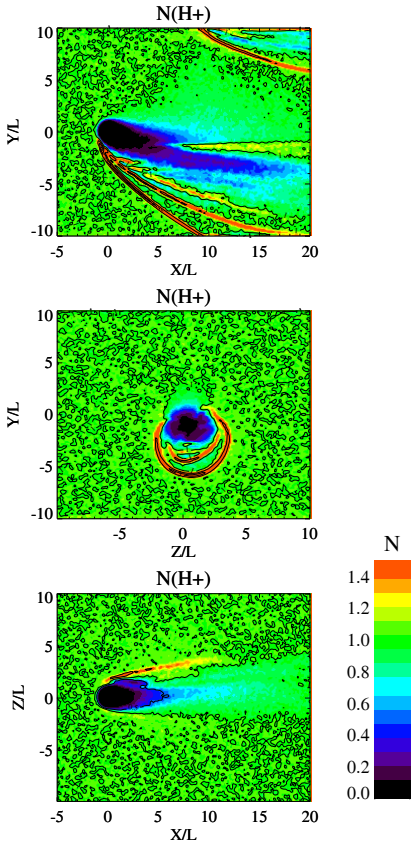

Figure 1: Solar wind density profiles.

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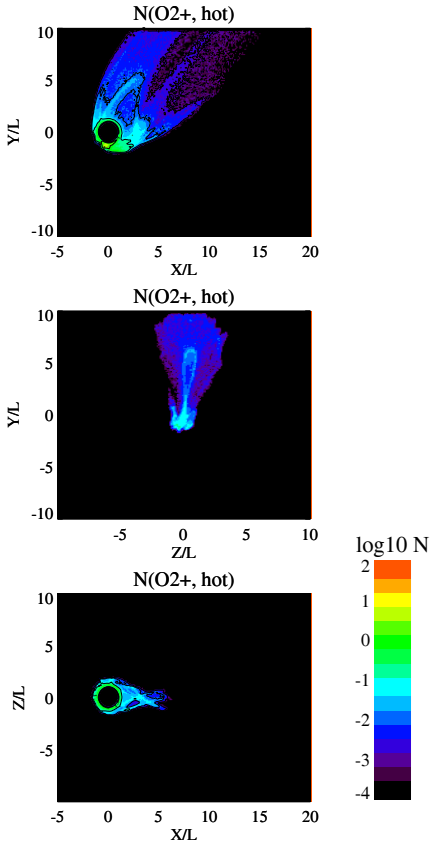

Figure 2: Pickup ion (O_2^+) density profiles. $M_A = 5.17$; $B_0 = 5.2\,\mathrm{nT}$; $U_0 = 305\,\mathrm{km/s}$; $N_{sw} = 3\,\mathrm{cm}^{-3}$; $\theta_{bw} = 78^\circ$