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Jovian's plasma torus interaction with Europa. E12 pass: 3D hybrid kinetic modeling

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Abstract

The hybrid kinetic model supports comprehensive simulation of the interaction between different spatial and energetic elements of the Europa moon-magnetosphere system with respect to variable upstream magnetic field and flux or density distributions of plasma and energetic ions, electrons, and neutral atoms. This capability is critical for improving the interpretation of the existing Europa flyby measurements from Galileo orbital mission and for planning flyby and orbital measurements for future missions. The simulations are based on recent models of the atmosphere of Europa [1, 2, 3]. The upstream parameters have been chosen from the plasma and magnetic field Galileo E12 observations, [4, 5].

In contrast to previous approaches with MHD simulations, the hybrid model allows us to fully take into account the finite gyroradius effect and electron pressure, and to correctly estimate the ions velocity distribution and the fluxes along the magnetic field [6]. Photoionization, electron-impact ionization and charge exchange are included in our model. The temperature of the background electrons and pickup electrons was also included into the generalized Ohm's law. The background plasma contains heavy ($M_i/Q_i = 16$) and light ($M_i/Q_i = 1$) ions [4]. In our modeling we take into account only O^+ ions for magnetospheric plasma. The pickup ions were created from the atmosphere. The majority of O_2 atmosphere is thermal with an extended non-thermal population [1]. The moon is modeled in this initial work as a weakly conducting body. The critical point of E12 pass is the extremely high density in upstream plasma, e.g. $n_0 = 70 - 571\,\mathrm{cm}^{-3}$ for ions with M_i/Q_i ratio equals 16. This density results in to the superAlfvénic flow and it will change the physics of the interaction between Jovian magnetosphere and Europa. The modeling show the formation of the Mach cone instead of the Alfv'en wing which was observed in hybrid modeling of E4 pass [6]. The modeling shows that the effective size of the oxygen exosphere for E12 pass is smaller than it was observed in case of E4 pass due to much higher pressure in the upstream plasma. In this report we also discuss the magnetic effects of the ocean conduction in case of E12 and E4 passes.

Acknowledgments

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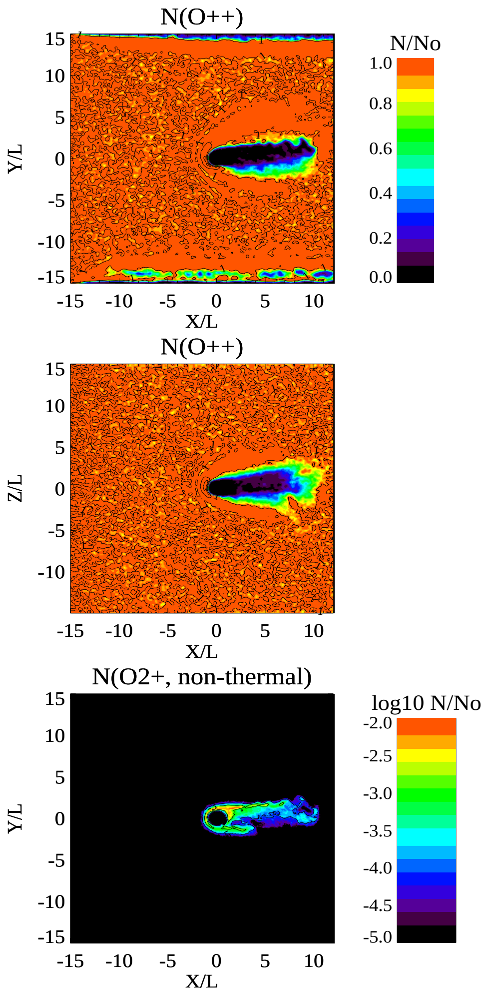

Figure 1: Background and pickup $O^+_{2,nonterm}$ ion density profiles. $M_A = 1.4$; $B_0 = 474\,\mathrm{nT}$; $U_0 = 101\,\mathrm{km/s}$; $N_0 = 400\,\mathrm{cm}^{-3}$

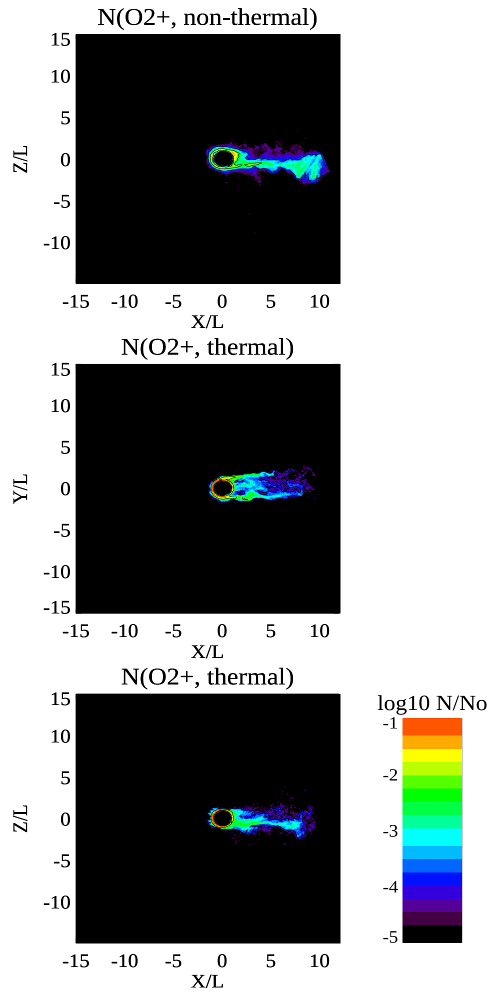

Figure 2: Pickup ion ($O^+_{2,nonterm}$, $O^+_{2,term}$) density profiles