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3D hybrid modeling of the plasma environment near Titan for T5 encounter

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Abstract

Wave-particle interactions play a very important role in the plasma dynamics near Titan: mass loading, excitation of low-frequency waves and formation of the particle velocity distribution function (e.g. ring/shell-like distributions, etc.) The kinetic approach is important for estimating collision processes; e.g., charge exchange. In this report we discuss results of 3D hybrid modeling of the interaction between Saturn's magnetosphere and Titan's atmosphere/ionosphere for T5 encounter. T5 flyby is the only encounter when the 2 main ionizating sources of Titan atmosphere, solar radiation and corotating plasma, align quasi-anti-parallel. The modeling is based on recent analysis of the Cassini Plasma Spectrometer (CAPS) and the Cassini Ion, and Neutral Mass Spectrometer (INMS) measurements during the T5 flyby through Titan's ram-side and polar ionosphere [1, 2]. Magnetic field data was used from the MAG instrument [3]. In our model the background ions (O^+, H^+), all pickup ions, and ionospheric ions are considered as a particles, whereas the electrons are described as a fluid (see e.g. [4]). Inhomogeneous photoionization (in the dayside ionosphere), electron-impact ionization, and charge exchange are included in our model. The temperature of the background electrons and pickup electrons was also incorporated into the generalized Ohm's law. We also take into account collisions between ions and neutrals. In our hybrid simulations we use Chamberlain profiles for the exosphere's components. The moon is considered as a weakly conducting body. The first results of our hybrid modeling show a strong asymmetry in the background (H^+, O^+) and pickup (H_2^+, N_2^+, CH_4^+) ion density profiles. Such strong asymmetry cannot be explained by a single-fluid multi-species 3D MHD model [5], which included complex chemistry but does not produce finite gyroradius and kinetic effects.

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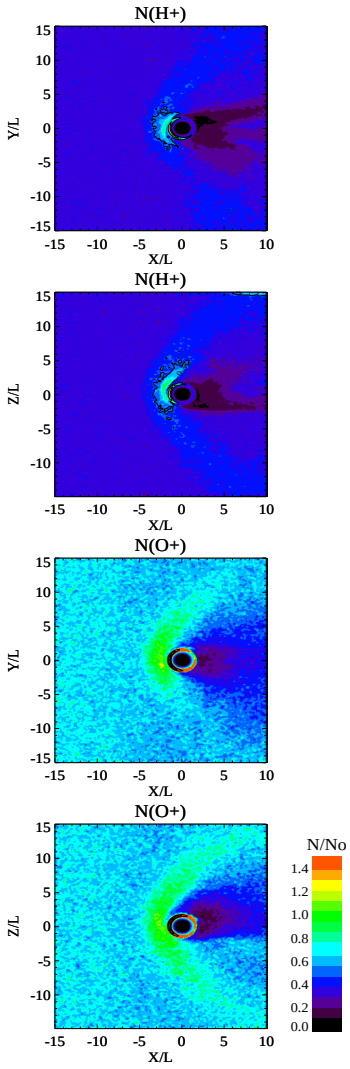

Figure 1: Solar wind density profiles. $N_{H^+} = 0.05\,\mathrm{cm}^{-3}$, $N_{O^+} = 0.1\,\mathrm{cm}^{-3}$, $N_0 = 0.15\,\mathrm{cm}^{-3}$

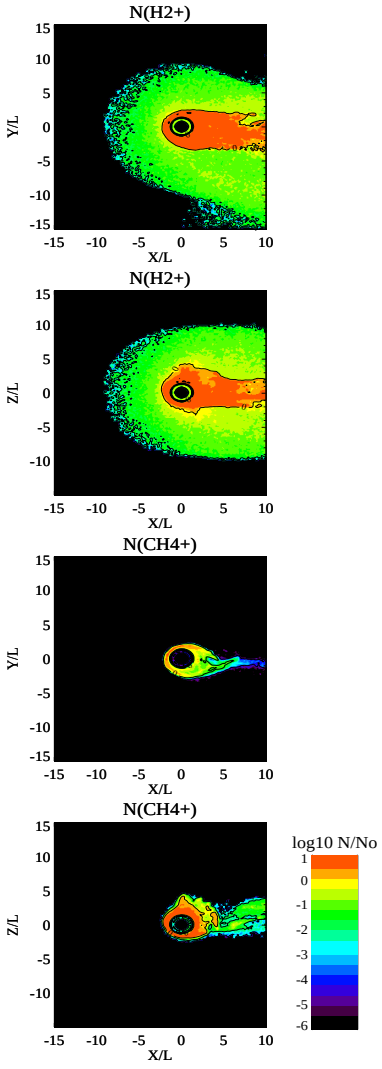

Figure 2: Pickup ion (H_2^+, CH_4^+) density profiles. $M_A = 1.5$; $B_0 = 6.8\,\mathrm{nT}$; $U_0 = 120\,\mathrm{km/s}$