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Imaging of energetic neutral atoms with the Jovian Neutral Atoms Analyser onboard JUICE: Charge exchange ENAs near Ganymede

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Abstract

The Jovian Neutral Atoms Analyser (JNA) is one of the sensors of the Particle Environment Package (PEP) for the JUICE mission. Mapping of the energetic neutral atoms (ENAs) in the Ganymede magnetosphere, will offer valuable clues about the interaction of the Jovian plasma with the icy moon's surface and the magnetospheric plasma processes. We will present expectations of neutral fluxes, particularly neutrals produced via charge exchange, in the vicinity of Ganymede. From these expectations from our model we infer the expectations for JNA measurements.

1. Introduction

The Jovian system is subject to complex plasma physics processes and can therefore be considered as a giant particle accelerator. Due to the plasma interactions, the Jovian moons are affected by diverse processes that lead to a vast range of space weathering effects and to a constant mass input to the environment of the moons.
Ganymede possesses a strong intrinsic magnetic field that imposes restrictions on the possible trajectories of plasma ions in the Ganymede magnetosphere [1]. As a result, certain terrains on the surface of the Jovian moon are protected against space weathering processes while others are not.

The JNA onboard the JUICE spacecraft will measure energetic neutral light and heavy atoms in an energy range from 10eV to 3keV [2], which covers the energy range of ENAs emanating from various different ENA production mechanisms. Low energy ENAs produced via sputtering and backscattering will be used to image the precipitation regions and, in particular, the boundary of open and closed field lines. In addition, ENAs are expected to be produced by the charge – exchange mechanism in the vicinity of Ganymede due to the presence of the moon's exosphere. From the measurement of these ENAs, we can infer the global plasma distribution in the Ganymede magnetosphere.
In this study we investigate the interaction between the Jovian plasma and the Ganymede magnetosphere and exosphere. In the Jovian system these interactions of the co-rotating magnetospheric plasma with the icy moons give rise to several observative effects, like for example the UV-aurorae observed on Ganymede [6].
The energy balance in terms of mass and radiation balance is one key scientific question of the mission as well as the surface and exosphere composition of the Jovian moons [4]. The direct measurements of mass flux by the JNA will undoubtedly contribute to answer these questions.

2. Model

To calculate the expected fluxes of ENAs, and particularly those resulting from the charge exchange processes, we combined the plasma spatial and velocity distribution modelled by hybrid simulation [5], the exospheric density model for Ganymede [8], and the charge exchange cross sections [7].

The simulations were run for hydrogen and oxygen, since these are the prominent species, particularly in the energy range covered by the JNA measurements. Fig. 1 shows the locations of hydrogen plasma particles from [5] in the GPhiO system as a snapshot in time. The co-rotating Jovian plasma precipitates on the Ganymede magnetosphere from the rear (from $-x$ direction), causing a void in front of the moon, seen in direction of its trajectory along the orbit.

Placing a virtual JNA instrument in the simulation, we can, under consideration of the JNA performance, derive a prediction of the expected neutral fluxes in the instrument. Our studies are a crucial contribution to the planning of the JNA mission operation and to the preparation of the PEP instruments for Ganymede science.

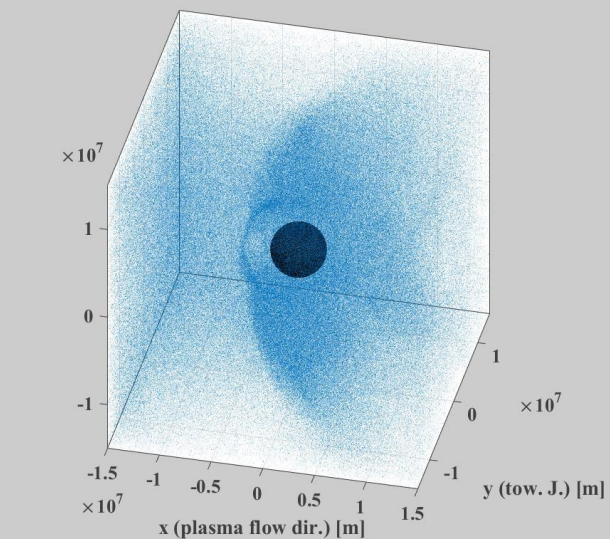

Figure 1 *Spatial distribution of H^+ in the vicinity of Ganymede, reproduced from [5]. Shown in the GPhiO system, the Jovian plasma flow is in +x direction and Jupiter is located towards + y.*

3. Summary

The JNA instrument, one of the sensors of the PEP scientific payload on the JUICE mission, will measure ENAs in the Ganymede magnetosphere and exosphere. These measurements will greatly contribute to our understanding of the interaction of the Jovian plasma with Ganymede, its icy surface and its intrinsic magnetic field. Based on a hybrid model we derived the neutral fluxes produced by charge exchange processes of high energetic plasma particles and neutral atoms in the Ganymede exosphere and the resulting fluxes expected to be measured by the JNA. We present our model, the resulting observations and the ENA fluxes along the JUICE Ganymede orbit expected to be measured by the JNA instrument.

Acknowledgements

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