EPSC Abstracts
Vol. 8, EPSC2013-356-1, 2013
European Planetary Science Congress 2013
© Author(s) 2013

Investigation of the atmospheres of Europa, Ganymede, and Callisto with PEP/JUICE

Audrey Vorburger (1), Peter Wurz (1), Marek Tulej (1), Nicolas Thomas (1), Stas Barabash (2), Martin Wieser (2), Helmut Lammer (3) and the PEP Team
(1) Universität Bern, Physikalisches Institut, 3012 Bern, Switzerland (vorurger@space.unibe.ch, 41 31 631 85 46), (2) Swedish Institute of Space Physics, S-981 28 Kiruna, Sweden , (3) Austrian Academy of Sciences, A-8042 Graz, Austria

Abstract

The JUpiter ICy moons Explorer (JUICE) is a planned ESA mission to the Jovian system. The mission's goal is to investigate in detail Jupiter and its system, with focus on the three Galilean moons Europa, Ganymede and Callisto. The Neutral Ion Mass Spectrometer (NIM), one of the sensors making up the Particle Environment Package (PEP), will contribute to this goal by conducting the first-ever direct sampling of the exospheres of Europa, Ganymede, and Callisto. Since the composition of these exospheres is largely unknown we calculated the expected density profiles. Our results show that NIM's sensitivity, mass resolution and mass range will be sufficient for NIM to detect most of the known and expected species in the icy moons' atmospheres.

1. Introduction

In early May 2012 ESA announced the selection of JUICE as the first large-class mission of the ESA Cosmic Vision Program 2015-2015. The launch is planned for June 2022, which would put JUICE in the Jovian system by 2030. In February 2013, 11 scientific instruments have been selected to fly on JUICE. One of these 11 instruments is PEP. PEP will deliver a 3D view of the Jovian Plasma system by measuring ions, electrons, energetic neutral atoms (ENAs) and neutral gas simultaneously over nine decades of energy from <0.001 eV to >1 MeV with full angular coverage. To achieve this full particle, energy and angular coverage, PEP incorporates six different types of sensors, one of which is NIM.

2. NIM Instrument

NIM is a highly sensitive neutral gas and ion mass spectrometer designed to measure the exospheric neutral gas and thermal plasma at Jupiter's moons with a very high mass resolution and unprecedented sensitivity. The detection level for neutral gas is $1 \cdot 10^{-16}$ mbar for a 5-second accumulation time (Wurz et al., 2012), which corresponds to a particle density of about 1 cm^{-3}. The mass resolution is $M/\Delta M > 1100$ in the mass range 1–1000 amu and NIM's energy range is $\leq$ 5e V for neutrals and <10 eV for ions.

NIM's science goal is to analyze the extended atmospheres of Europa, Ganymede and Callisto, in particular the neutral and the ionized component. The main scientific goals are to:

- determine the atmospheres' composition
- identify the ion composition of the ionosphere
- analyze geysers and their temporal evolution
- conduct isotopic analysis
- assist in the investigation of surface composition

3. Jovian Icy Moons' Atmospheres

Various physical processes promote material from the icy moons' surfaces into the exosphere. These processes include thermal desorption, photon stimulated desorption, ion-induced sputtering, and micrometeorite impact vaporisation (Wurz and Lammer, 2003; Wurz et al., 2010). At Europa, sputtering, the most important process, releases all species present on the surface more or less stoichiometrically into the exosphere. This allows to infer the chemical composition of the surface from exospheric measurements. We modeled the processes in Europa's atmosphere and determined that at altitudes higher than 400 km (JUICE's closest approach) the main species present are:

- O_2 (sputtered)
- H_2 (thermal)
- H_2O (sputtered)
- O (from O2)
- H (thermal)
- Na (sputtered)

with the exact densities for these and other species shown in Figure 1.

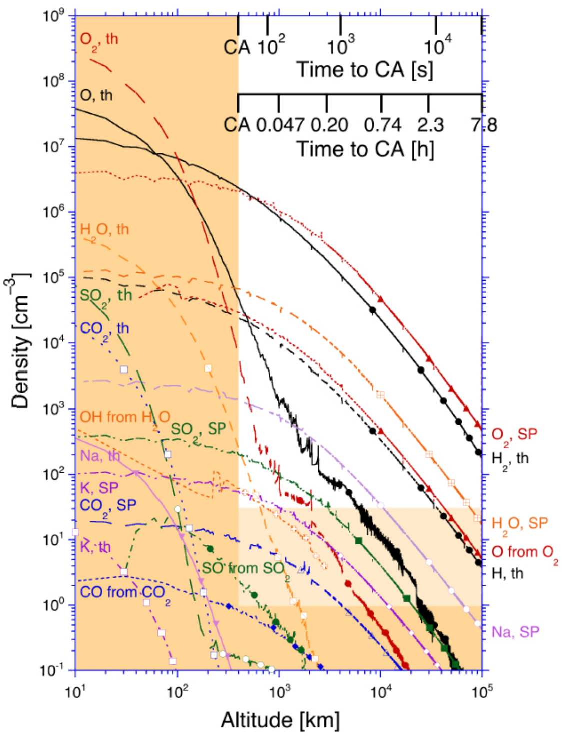

Figure 1: Calculated densities in Europa's exosphere at the day-side based on literature reports. White and light brown areas indicate the range of possible NIM measurements during Europa flyby. Left boundary is given by the 400 km flyby altitude at closest approach, lower boundary by the NIM sensitivity. The light brown area corresponds to the end-of-life NIM performance.

Much less is known about the composition and densities of the exospheres of Ganymede and Callisto. The expected species in Ganymede's atmosphere are H_2, H_2O, O_2, OH, O, H and traces of species originating from hydrogen salts located on the surface (McCord et al., 2001). In the case of Callisto, a CO_2 exosphere was detected (Carlson, 1999) and an O_2 rich exosphere containing water molecules is expected (Liang et al., 2005). We will use the available data to compute and present density profiles for Ganymede and Callisto.

4. Summary and Conclusions

According to NIM specifications, NIM will be able to measure all species known as well as species expected (Mg, Al, Si, and Ca,) form non-ice surfaces in Europa's exosphere. In addition, D/H ratios as well as $^{18}O/^{16}O$ ratios can be resolved. The identification of yet undiscovered species, with likely candidates from the non-ice materials will help understand the mineralogical composition of the surfaces of the moons. NIM, with its high mass resolution, range and sensitivity, will be able to help contribute to the habitability assessment of Europa by being able to investigate localized patchy regions of the exosphere indicative of sub-surface venting and to resolve chemical composition. Most important, NIM will help to investigate the potential for the emergence of life in the galactic neighborhood and beyond.

Acknowledgements

A. Vorburger, P. Wurz, M. Tulej and N. Thomas gratefully acknowledge the financial support by the Swiss National Science Foundation.

References

[1] Carlson, R. W., Science 283 (5403), 820–821, 1999

[2] Liang, M.-C., et al., J. Geophys. Res., 110, E02003, 2005

[3] McCord, T. B., et al., Science, 292 (5521), 1523-1525, 2001

[4] Wurz, P., and H. Lammer, Icarus, 164 (1), 1-13, 2003

[5] Wurz, P., et al., Planetary and Space Science, 58 (12), 1599-1616, 2010

[6] Wurz, P., et al., Sol. Sys. Res. 46, 442-459, 2012