EPSC Abstracts
Vol. 12, EPSC2018-497, 2018
European Planetary Science Congress 2018

Europa's Ice-Related Atmosphere: The Sputter Contribution

Audrey Vorburger (1), Peter Wurz (1), and André Galli
(1) Physikalisches Institut, University of Bern, 3012 Bern, Switzerland (vorburger@space.unibe.ch)

Abstract

Europa, the innermost and smallest of the four Galilean moons orbiting Jupiter, is constantly bombarded by Jupiter's magnetospheric plasma. This plasma interaction, together with sublimation during the day, lead to the formation of a tenuous atmosphere, also called exosphere. In this work we present the sublimation and sputter contribution to Europa's exosphere, computed by Monte-Carlo modeling. In addition, we will compare the resulting density curve to the measurement capabilities of PEP / NIM on JUICE.

1. Introduction

Europa, Jupiter's innermost icy satellite, is embedded well within Jupiter's magnetospheric plasma, an intense flux of ions and electrons that approximately co-rotate with Jupiter. With Jupiter's rotation period being substantially shorter than Europa's orbital period, the Jovian plasma constantly flows over Europa from its trailing hemisphere and sweeps ahead of it on its orbital motion. The plasma itself can be thought of as consisting of two populations: the cold, thermal plasma with energies ranging from eV to keV and the hot, energetic plasma with energies ranging from keV to MeV. As the plasma encounters Europa's icy surface, two processes are dominating with respect to the atmosphere: radiolysis, altering the ice physically and chemically, and sputtering, which releases surface material from the ice matrix to form a tenuous atmosphere.

2. JUICE Mission

In early May 2012 ESA announced the selection of JUICE as the first large-class mission of the ESA Cosmic Vision Program 2015-2015 [1]. 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, the Particle Environment Package [2]. 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, the Neutral and Ion Mass spectromenter.

3. NIM Instrumentation

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 10^{-16} mbar for a 5-second accumulation time [3], which corresponds to a particle density of ~1 cm^{-3} . The mass resolution is $M/\Delta M > 1100$ in the mass range 1–1000 amu, and NIM's energy range is ≤ 5 eV 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.

4. Monte-Carlo Modeling Results

In this work we calculate the sputter contribution of Europa's icy surface to its exosphere, and show that both the cold, co-rotating thermal plasma as well as the hot, omnidirectional energetic plasma are of comparable importance for the formation of Europa's exosphere. Our modeling results are based completely on first principles, that is no scaling of surface fluxes to observed densities are applied. Instead, we apply current best knowledge of Jupiter's plasma properties, as well as most recent laboratory results on ice sputter yields to our Monte Carlo model, to calculate Europa's exosphere ab initio. In particular, this work is the first to incorporate laboratory measurements of electron ice sputter yields in an Europa atmosphere calculation. Similarly to previous modeling results, our calculations show that Europa's exosphere is dominated by a bound, thermalized O_2 atmosphere close to the surface (below ~1000 km), and by an extended corona of light H_2 molecules at higher altitudes.

5. Summary and Conclusions

According to NIM specifications, NIM will be able to measure all water-related species in Europa's exosphere. Both the thermalized O_2 atmosphere close to the surface and the extended corona of light H_2 molecules at higher altitudes will be clearly visible in the NIM mass spectra.

Our models will help to distinguish between different exospheric components (e.g. sublimated versus sputtered contributions), and explain variability in Europa's exosphere due to changing conditions.

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.

References

[1] Grasset, O., Dougherty, M.K., Coustenis, A., Bunce, E.J., Erd, C., Titov, D., Blanc, M., Coates, A., Drossart, P., Fletcher, L.N., Hussmann, H., Jaumann, R., Krupp, N., Lebreton, J.-P., Prieto-Ballesteros, O., Tortora, P., Tosi, F., Hoolst, T.V., 2013. JUpiter ICy Moons explorer (JUICE): an ESA mission to orbit ganymede and to characterise the jupiter system. Planet. Space Sci. 78, 1–21. doi: 10.1016/j.pss.2012.12.002 .

[2] Barabash, S., Wurz, P., Brandt, P., Wieser, M., Holmström, M., Futaana, Y., Stenberg, G., Nilsson, H., Eriksson, A., Tulej, M., Vorburger, A., Thomas, N., Paranicas, C., Mitchell, D.G., Ho, G., Mauk, B.H., Haggerty, D., Westlake, J.H., Fränz, M., Krupp, N., Roussos, E., Kallio, E., Schmidt, W., Szego, K., Szalai, S., Khurana, K., Jia, X., Paty, C., Wimmer-Schweingruber, R.F., Heber, B., Kazushi, A., Grande, M., Lammer, H., Zhang, T., McKenna-Lawlor, S., Krimigis, S.M., Sarris, T., Grodent, D., 2013. Particle environment package (PEP). In: Proceedings of the European Planetary Science Congress 2013, 8, p. 709 . held 8–13 September, London, UK.

[3] Wurz, P., Vorburger, A., Galli, A., Tulej, M., Thomas, N., Alibert, Y., Barabash, S., Wieser, M., Lammer, H., 2014. Measurement of the Atmospheres of Europa, Ganymede, and Callisto. European Planetary Science Congress 9 EPSC2014-504 .