Europa's interaction with the jovian plasma from hybrid simulation

Claire Baskevitch[1,2], Ronan Modolo[1], Baptiste Cecconi[2]

[1]UMR8190, LATMOS (CNRS/Sorbonne Université), 4 place Jussieu, 75252 Paris, France
[2]UMR8109, LESIA Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université de Paris, 5 place Jules Janssen, 92195 Meudon, France

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JUICE mission and Europa

- Europa is the smallest of the Galilean moons with a radius of 1560km. Its orbital radius is about 9 Jovian radii.
- Under its icy crust lies a liquid salt ocean generating convective currents that induce a weak magnetic field. Presence of water vapour plumes ejected from the surface and located at the south pole was discovered by HST.

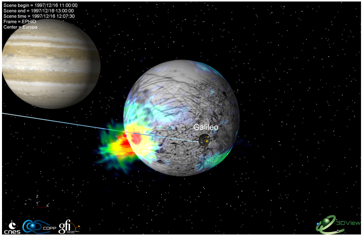


Figure: 3D representation of a plume from an Exospheric Global Model simulation. credit : F. Leblanc

- Its tenuous atmosphere is mainly composed of O_2 (sputtering), H_2O (sublimation and sputtering) and $H2$.
- The ionosphere is mainly composed of O_2^+ and O^+, whose main ionisation reactions are electronic impact and photoionisation.
- The plasma in the vicinity of Europa is composed of oxygen and sulphide ions, which originate from Europa's ionosphere and Io's torus.
- JUICE (JUpiter ICy moons Explorer), the next L-class ESA mission will explore the three icy moons of Jupiter: Ganymede, Europa and Callisto. Within the scope of this mission, preliminary work is being carried out to predict the observations.
- **The simulation work conducted aims to describe the environment of the moon and to characterise the moon-magnetosphere interaction**

LatHyS model

LatHyS

- LatHyS is a hybrid, three-dimensional, multi-species simulation model of the plasma-planetary environment interaction.
- The term hybrid refers to the representation of ions as particles and electrons as a fluid in the simulation.
- Electromagnetic fields are computed self-consistently.

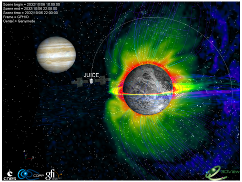


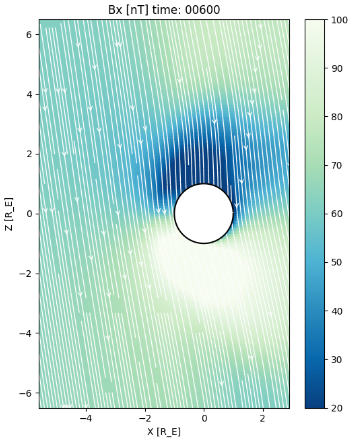
Figure: Ganymede's environment was developed by Leclercq et al, JCP, 2016.

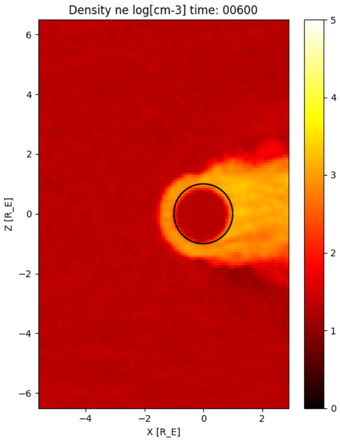
Planetary properties

- The ionosphere is composed of O_2^+. It follows a profile of two height scales (240 and 440km, Kliore et al. 1997) and a maximum density at the surface has been taken to 2500cm^{-3} which is less dense than the 5000cm^{-3} of the radio-occultation observations (Kliore et al, 1997) but comparable to the MHD findings (Harris et al, 2021)
- The Jovian plasma is composed of O^+ with a velocity of 100km/s and a density of 20cm^{-3}. (Harris et al, 2021)
- The jovian magnetic field used is $(55, -173, -412)nT$ corresponding to an average value of the jovian field between E4 inbound and oubound pass. Europa's induced magnetic field is represented by a centered dipole (Harris et al, 2021)

- Work in progress : Work is carried out on open boundary conditions rather than periodic conditions in order to reduce the size of the simulation box and thus reduce the cost in resources and execution time.

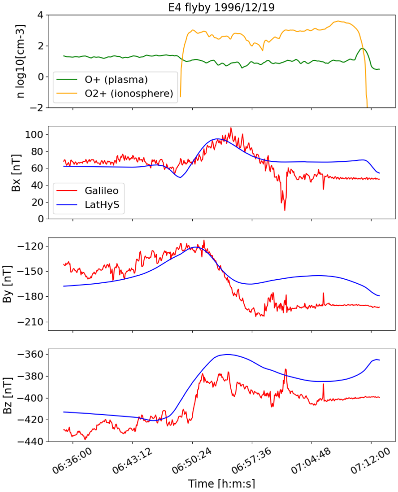
Preliminary results

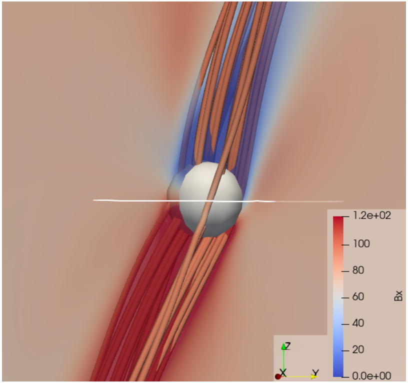




- Bx in XZ plan. X points towards corotation and Z towards Jupiter's north pole.
- Electron density in XZ plan.

Preliminary results : Comparison with Galileo E4 flyby





- In general, the simulation reproduces the main trend of the Europa's magnetic field observations.
- It can be noted that the ionospheric ion density does not decrease beyond 6:57 (exit from the ionosphere) and tends to increase, affecting the magnetic field.

Conclusion and references

- The comparison of the results with the galileo data is encouraging and the next objective is to define a more realistic ionosphere by integrating ionisation processes into the simulation.
- The work on open conditions continues. The rate of optimisation is encouraging, which motivates us to continue to look for the most efficient parametrisation that reduces numerical errors and the resulting disturbances to a minimum.

- References

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