The radiation belts of Jupiter as seen by the physical model Salammbô

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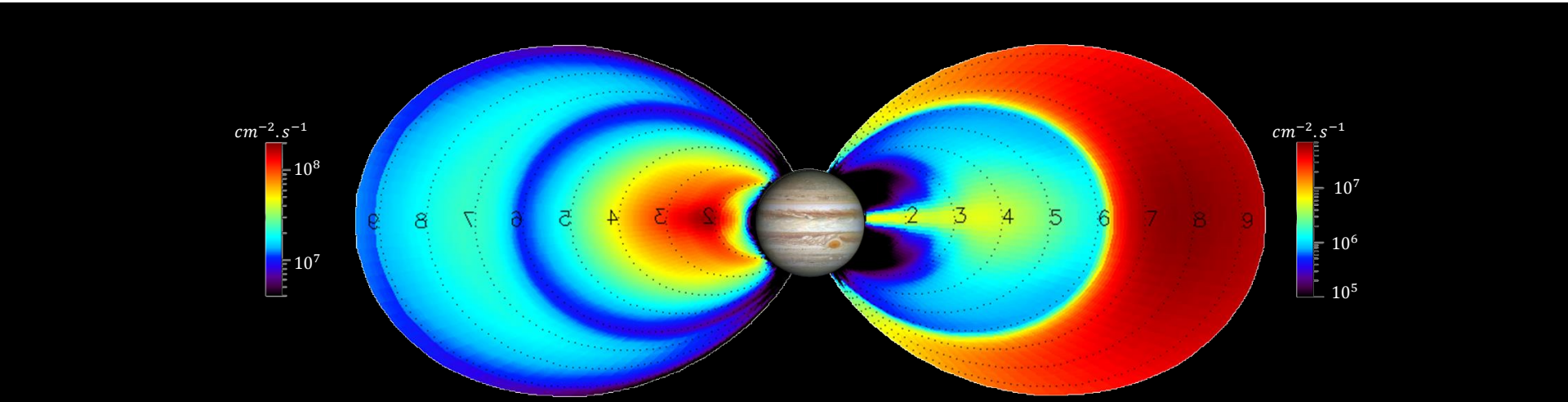
In brief

- A physical model, named Salammbô, of the energetic electrons and protons inward of Europa's orbit (9 Rj) is presented and validated against observations
- Resonant interactions with electromagnetic waves (EMIC, Hiss and chorus) limit electron and proton fluxes near the orbit of the volcanic moon Io (6 Rj)

What are radiation belts or « Van Allen » belts ?

- Relativistic charged particles (electrons, protons and heavier ions) that are trapped by planetary magnetic fields : are known to exist around Earth, Jupiter, Saturn, Uranus and Neptune
- Jupiter has the largest, most energetic belts with the most extreme particle fluxes: major threat to exploration missions



Meridian plot of particle fluxes predicted by the physical model Salammbô. Left : electrons with $E_k > 5\ MeV$. Right : protons with $E_k > 1\ MeV$
Credit for the Jupiter image: HST

Exploration of the Jovian radiation belts inside 9.5 Rj (1 Rj=71492km)

In-situ: Pioneer 10 (1973), Pioneer 11 (1974), Voyager 1 (1979), Galileo atmospheric probe (1995), Galileo Orbiter (1995-2003), Juno (2016 – now)

Remotely: observation by terrestrial radio-telescopes of the synchrotron radiation emitted by the electrons: VLA, GMRT, LOFAR

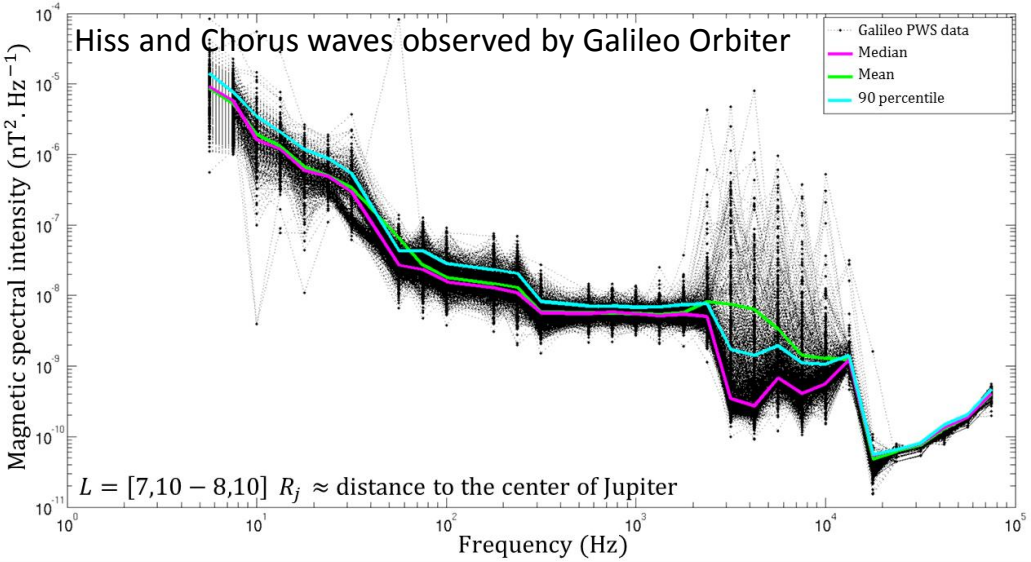
The physical model Salammbô and wave-particle interaction

Many physical processes shape the radiation belts, like absorption by the moons, radial transport, interactions with the Jovian atmosphere. **Wave-particle interaction has been recently added to the model.**

EM waves observations

Hiss and chorus waves (frequency > 5Hz) : Galileo-Plasma Wave Science (PWS)

ElectroMagnetic Ion Cyclotron (EMIC) waves : observed by the magnetometers of Galileo



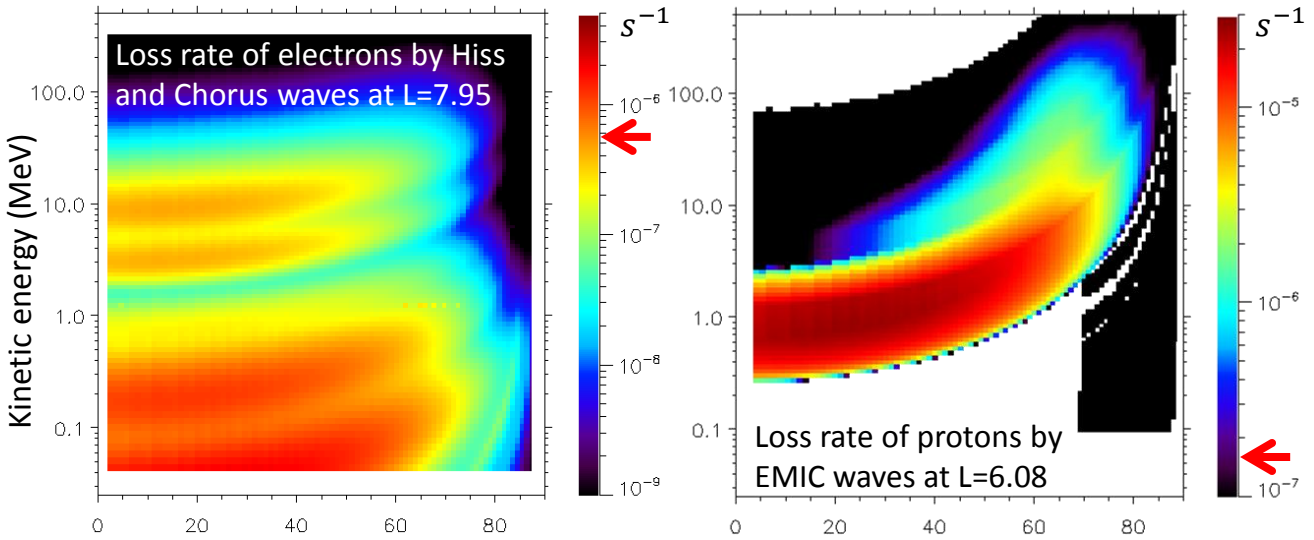
WAPI software

WAve-Particle Interaction (WAPI), developed by ONERA, enables to compute the effect of the EM waves on the trapped particles

Effect

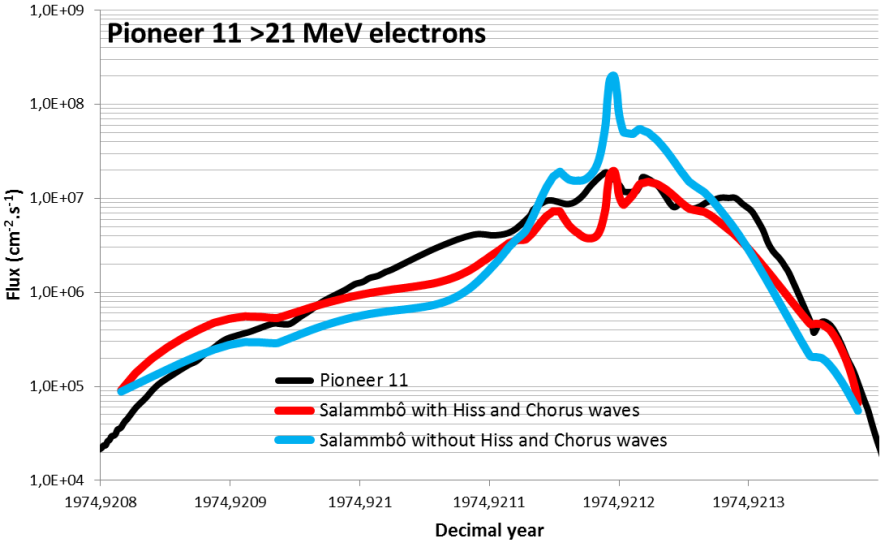
If the loss rate higher than the red arrow level (radial transport rate), the particle is precipitated in the atmosphere of Jupiter

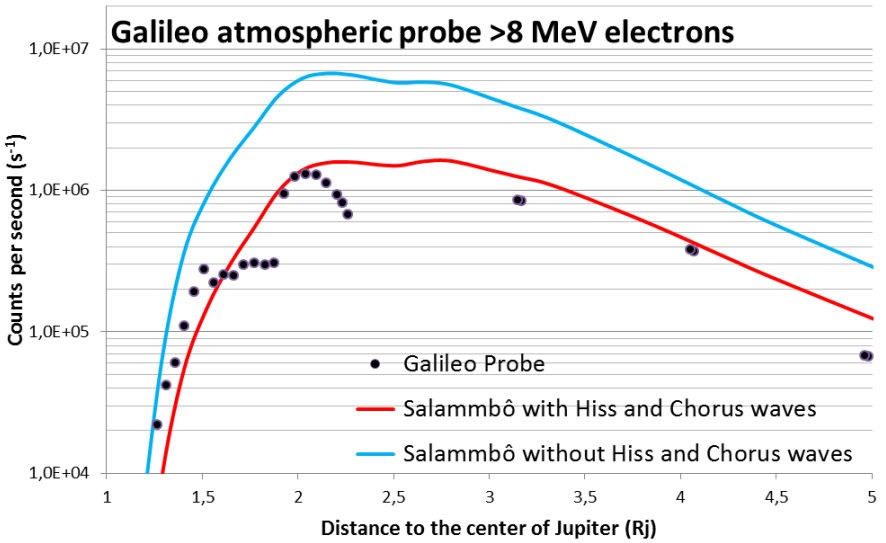
Conclusion: the EM waves observed by Galileo Orbiter remove particles from the radiation belts of Jupiter



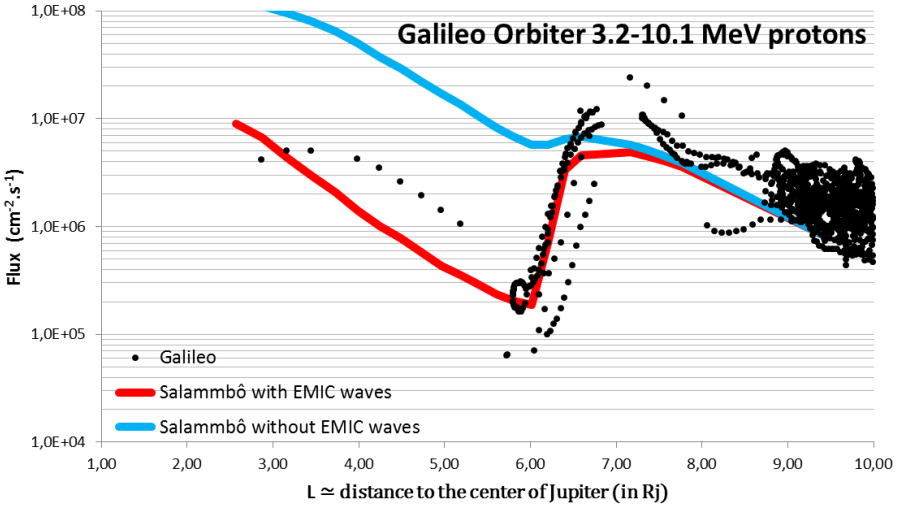
Validation of the Salammbô model against observations

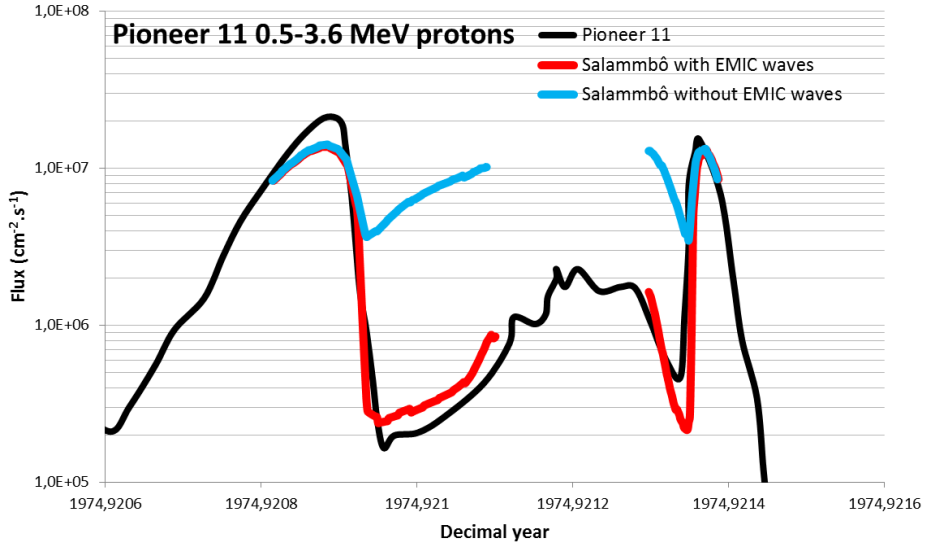
Electrons





Protons





The Salammbô model reproduces all existing observations within less than a factor of 3.

Wave-particle interaction is a dominant loss process. If not, fluxes in the radiation belts would be 10 to 50 times greater.

More details in two articles published in JGR: Space Physics: Nénon et al. [2017], Nénon et al. [2018]