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Cassini Grand Finale :
a dive into the very heart of Saturn's radio aurorae

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Just one year after the end of the Cassini mission, the data harvested during the « Grand Finale » is starting to yield its first results. In a paper published in a special issue of the journal *Science* dated October 5th 2018, an international team led by an astronomer from the Observatoire de Paris-PSL at the Laboratoire d'études spatiales et d'instrumentation en astrophysique (Laboratory for space studies and astrophysical instrumentation) - LESIA (Paris Observatory / CNRS / PSL / Sorbonne University / Paris Diderot University) has identified and characterized *in situ* the regions on Saturn which are responsible for its auroral radio emission.

Planets which have a magnetic field, like the Earth or the giant planets, generate luminous emission in the neighborhood of their magnetic poles: this emission is referred to as polar aurorae. They are the product of a flow of energetic particles, essentially electrons accelerated in the magnetosphere - the planetary magnetic environment – via various complex mechanisms, and subsequently channeled towards the planet along the high latitude magnetic lines of force. When they plunge into the atmosphere, these electrons generate radiation via collisions, a radiation which is observed in the optical domain (visible, ultra-violet or infra-red).

Above the atmosphere, as far out as several planetary radii, these same electrons also amplify radio waves. This radio emission is extremely intense. It is essential to studying this radiation *in situ in* in order to understand just how it is produced and how its study from a distance enhances our understanding of the magnetosphere. Moreover, a study of the magnetospheres of the planets in our solar system will lead to the establishment of a standard reference which will help us to interpret the radio emission of exo-planets, brown dwarves and stars, whose research is expanding rapidly.

During the «Grand Finale», the final stage of the Cassini mission, the space probe repeatedly flew over the magnetic poles at low altitude, just where Saturn's auroral radio emission is born. By analyzing the *in situ* data acquired by the probe's radio instrument and magnetometer, the authors of the paper have identified the «sources» of the far radio aurorae out to about 3 planetary radii (180 000 km) above the atmosphere. They have thus been able to characterize the properties of the radio waves and whence they are born, and thereby compare successfully observation with theoretical prediction.

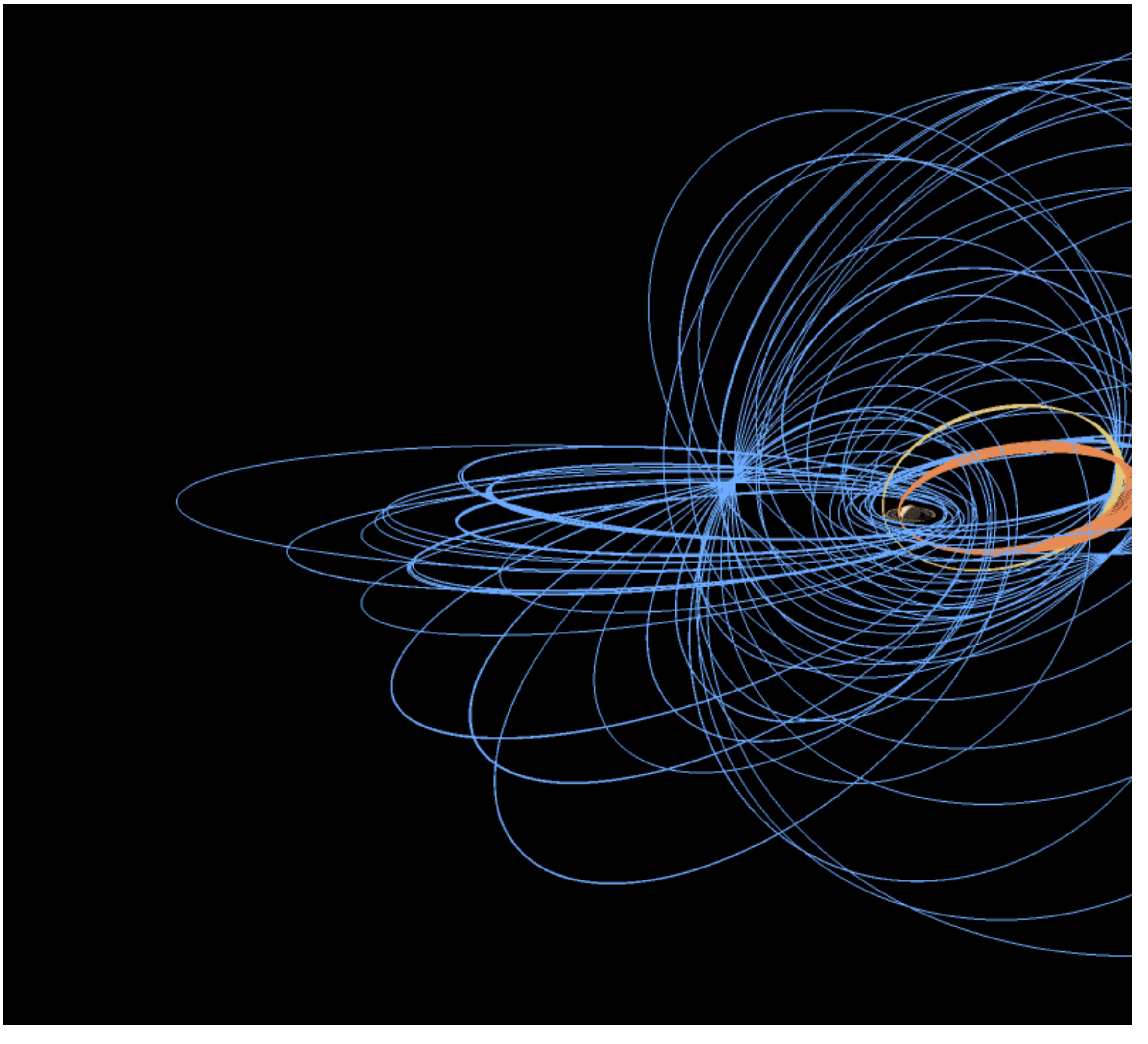
The result: Saturn's auroral radio emission is produced by the same process as that which has been identified on the Earth and recently on Jupiter – a plasma instability known as the Maser Cyclotron instability – which enables electrons, in this case having energies of several kilo-electron volts, to give up a part of their energy to radio waves as they gyrate around the magnetic lines of force.

Nevertheless, this mechanism functions under very different conditions than those known on the Earth. The regions responsible for the radio emission are very much farther out from the planet in the case of Saturn, and the electrons involved, measured locally, have had to have been accelerated towards the planet much farther out than the emission region, which somewhat shakes up our understanding of the acceleration mechanisms operating in the magnetosphere.

Furthermore, the radio sources were found on magnetic field lines connected in fact to specific regions where ultra-violet aurorae were observed at the same time by the Hubble space telescope in orbit around the Earth. The authors have shown that this partial association of distant radio sources and ultra-violet aurorae could be explained by a very variable local plasma density, whose origin has still to be identified and which is sometimes too high for the instability to operate.

These results confirm that one and the same universal mechanism can produce auroral radio waves in the environments of very different magnetic bodies.

Image

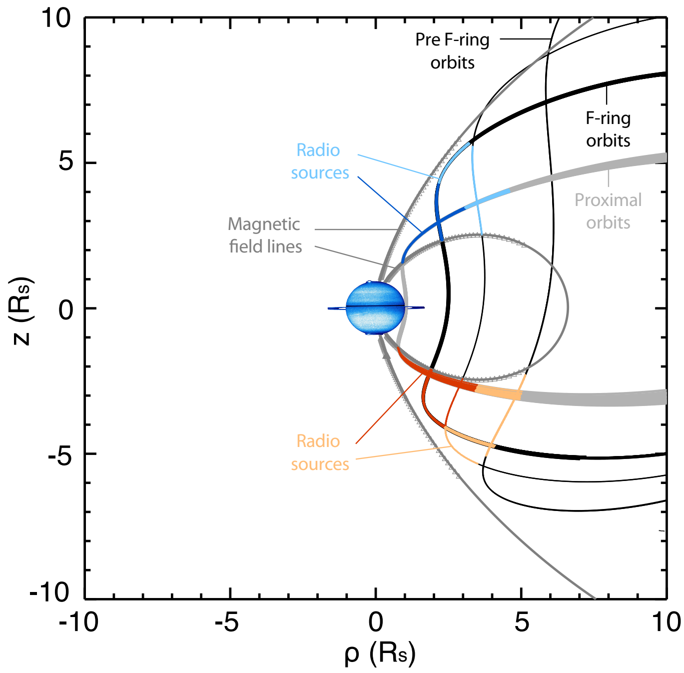


Caption: In this animated view created by Cassini's mission planning team, blue represents the Solstice mission orbits that began in 2010.

Yellow represents the 20 Ring-Grazing (F ring) Orbits, the penultimate science phase of the mission. Orange represents the 22 Grand Finale orbits - Cassini's final exciting science phase.

Credit: NASA/JPL-Caltech/Erick Sturm

Figures



Captions :
Paths projected onto a meridian plane of high latitude orbits during the « Grand Finale » of Cassini. The expected sources of Saturn's auroral radio emission (colored symbol) are localized on high latitude magnetic field lines (in grey). The study involved distant radio sources found during the orbits « F-ring » and « pre F-ring ».

Credit: L. Lamy, Observatoire de Paris – PSL

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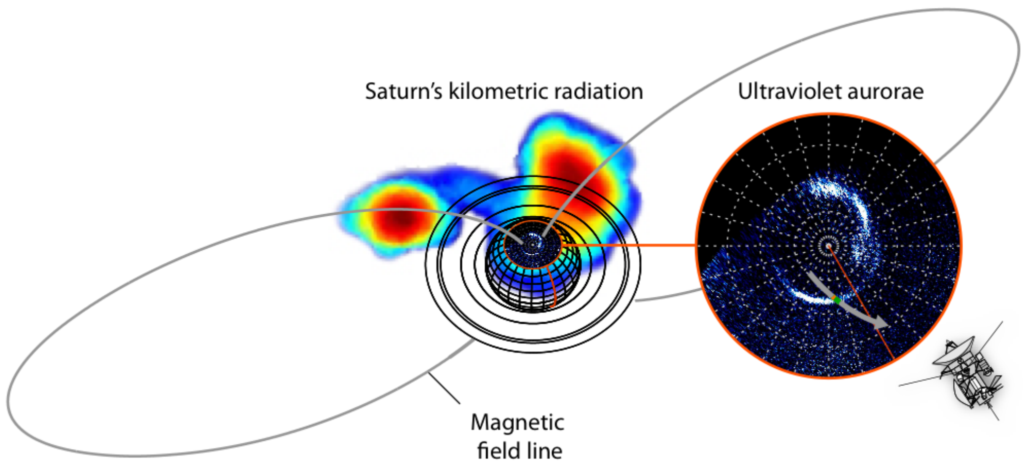

e left: Saturn's auroral radio emission as observed by the Cassini probe when crossing close to a radio source. The position of the radio emissions was found via a gonio-polarimetric analysis of the data acquired by the RPWS, an advanced radio instrument.
On the right: Ultra-violet aurorae observed at the same time by the Hubble space telescope. The grey arrow shows Cassini's magnetic foot points to the along its path. The region which corresponds to the radio source that is traversed (in orange) corresponds to the interior region of the auroral oval.
Credit: L. Lamy, Observatoire de Paris – PSL

Video

Paris Observatory's Youtube animation station: «Animated presentation of Saturn's kilometric radiation observations
https://www.youtube.com/channel/

Reference
The research is published as a paper entitled *“The low frequency source of Saturn's Kilometric Radiation," by L. Lamy, et.al.* in the October 5th 2018 issue of *Science*

The team includes four french researchers : Laurent Lamy (Observatoire de Paris – PSL), quatre chercheurs français : L. Lamy (astronome de l’Observatoire de Paris – PSL), P. Zarka (directeur de recherche CNRS), B. Cecconi (astronome de l’Observatoire de Paris – PSL), R. Prangé (directeur de recherche CNRS), and six others researchers : W. S. Kurth, G. Hospodarsky, A. Persoon, M. Morooka, J.-E. Wahlund, G. J. Hunt.