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Scientists directly observe electron dynamics of the Northern Lights

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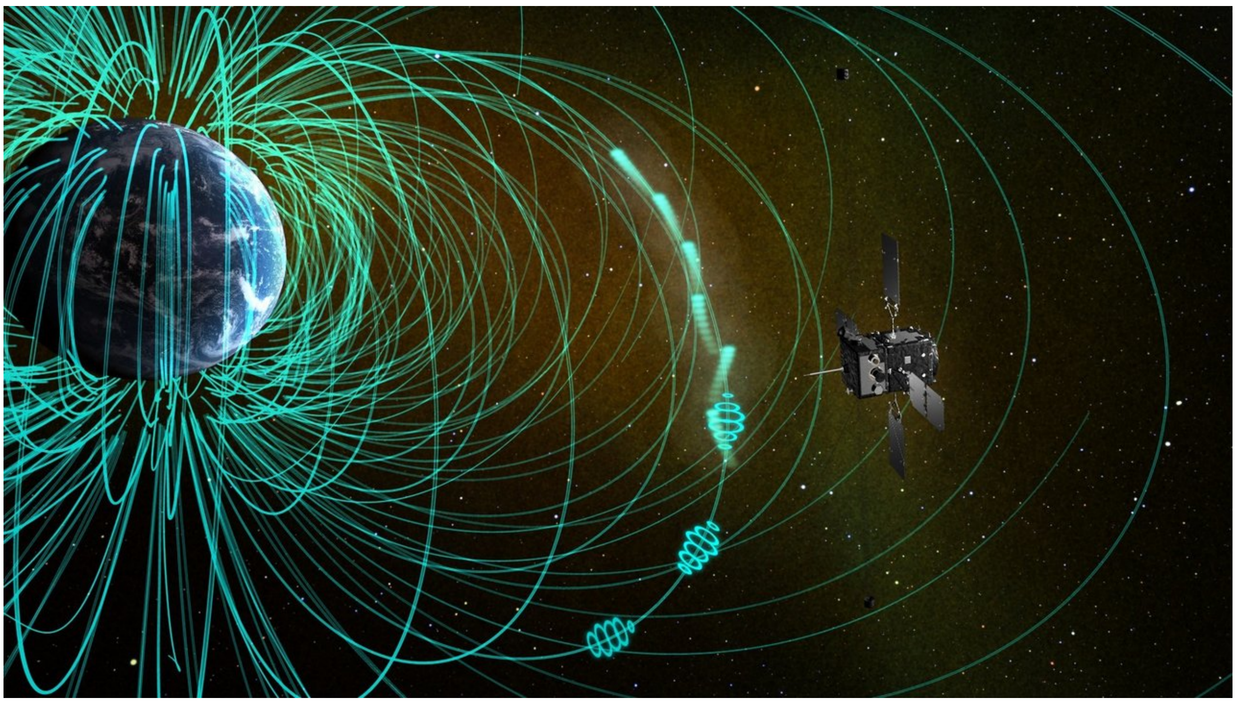

The ERG spacecraft observed chorus waves and scattered electrons in the magnetosphere, the origin of pulsation auroras. The scattered electrons precipitated into the atmosphere resulting in auroral illumination. Intermittent occurrence of chorus waves and associated electron scattering lead to auroral pulsation. Credit: 2018 ERG science team.

The shower of electrons bouncing across Earth's magnetosphere, commonly known as the Northern Lights, has been directly observed for the first time by an international team of scientists. While the cause of these colorful auroras has long been hypothesized, researchers had never directly observed the underlying mechanism until now. The results have been published in *Nature*.

The spectacle of the Northern Lights is a fantastic show widely considered to be one of the great natural wonders of the world. Among a variety of auroras, pulsating auroral patches appearing at dawn are common, but the physical mechanisms driving this auroral pulsation were never verified through observation.

With a new satellite carrying advanced measuring tools, researchers have now identified that this phenomenon is caused by the hard-to-detect interaction between electrons and plasma waves. This interaction takes place in the Earth's magnetosphere, the region surrounding the Earth in which the behavior of the electric particles is usually governed by the planet's magnetic field.

"Auroral substorms are caused by global reconfiguration in the magnetosphere, which releases stored solar wind energy," writes Satoshi Kasahara, an associate professor at the University of Tokyo in Japan, the lead author of the paper. "They are characterized by auroral brightening from dusk to midnight, followed by violent motions of distinct auroral arcs that eventually break up, and emerge as diffuse, pulsating auroral patches at dawn."

The global reconfiguration often drives a specific type of plasma wave called chorus waves to rain electrons into the upper atmosphere. This stabilizes the system, and gives off a colorful light as the electrons fall. However, scientists have questioned if the chorus waves were powerful enough to excite electrons to the extent of creating auroras.

"For the first time, we have directly observed scattering of electrons by chorus waves generating particle precipitation into the Earth's atmosphere," Kasahara says. "The precipitating electron flux was sufficiently intense to generate pulsating aurora."

Scientists couldn't see this direct evidence of electron scattering before because typical electron sensors cannot distinguish the precipitating electrons from others. Kasahara and his team designed a specialized electron sensor that detected the precise interactions of auroral electrons driven by chorus waves. The sensor was aboard the Exploration of Energization and Radiation in Geospace (ERG) satellite, also known as the Arase spacecraft, launched by the Japan Aerospace Exploration Agency.

The scientists plan to pursue this line of research further. "By analyzing data collected by the ERG spacecraft more comprehensively, we will reveal the variability and further details of plasma physics and resulting atmospheric phenomena, such as auroras," Kasahara says.

More information: S. Kasahara et al, Pulsating aurora from electron scattering by chorus waves, *Nature* (2018). DOI: 10.1038/nature25505

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