The story of polar aurora just got much bigger: Unknown magnetospheric mechanisms revealed

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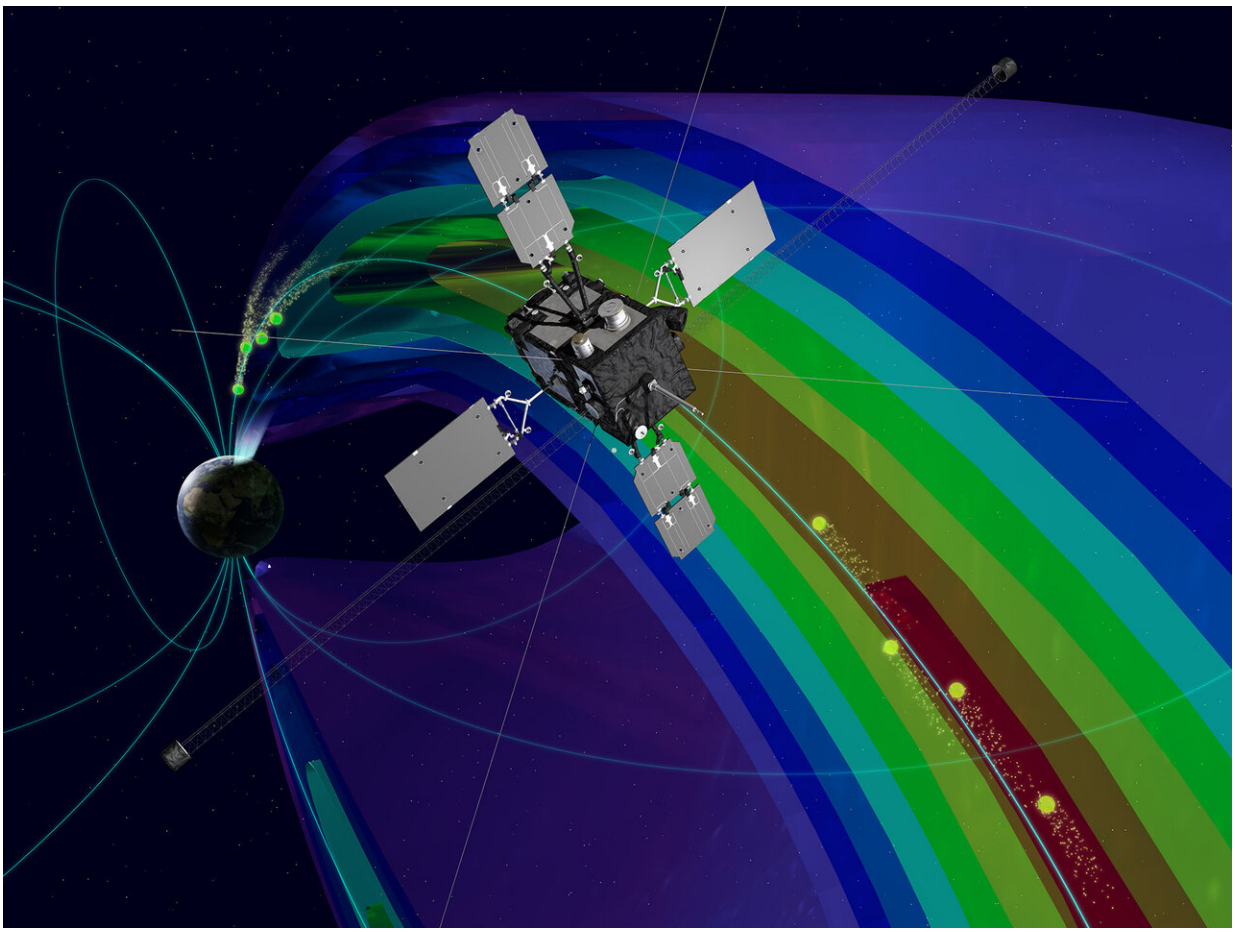

The Arase satellite captured data about electrons accelerated from very high altitudes. Credit: ERG science center

A critical ingredient for auroras exists much higher in space than previously thought, according to new research in the journal *Scientific Reports*. The dazzling light displays in the polar night skies require an electric accelerator to propel charged particles down through the atmosphere. Scientists at Nagoya University and colleagues in Japan, Taiwan and the U.S. have found that it exists beyond 30,000 kilometers above the Earth's surface—offering insight not just about Earth, but other planets as well.

The story of aurora formation begins with supersonic plasma propelled from the sun into space as high-speed, charged particles. When these charged particles get close to Earth, they are deflected and funneled in streams along the planet's magnetic field lines, eventually flowing towards the poles.

"Most electrons in the magnetosphere don't reach the part of the upper atmosphere called the ionosphere, because they are repelled by the Earth's magnetic field," explains Shun Imajo of Nagoya University's Institute for Space-Earth Environmental Research, the study's first author.

But some particles receive a boost of energy, accelerating them into Earth's upper atmosphere where they collide with and excite oxygen and nitrogen atoms at an altitude of about 100 kilometers. When these atoms relax from their state of excitation, they emit the auroral lights. Still, many details about this process remain a mystery.

"We don't know all the details of how the electric field that accelerates electrons into the ionosphere is generated or even how high above Earth it is," Imajo says.

Scientists had assumed electron acceleration happened at altitudes between 1,000 and 20,000 kilometers above Earth. This new research

revealed the acceleration region extends beyond 30,000 kilometers.

"Our study shows that the electric field that accelerates auroral particles can exist at any height along a magnetic field line and is not limited to the transition region between the ionosphere and magnetosphere at several thousand kilometers," says Imajo. "This suggests that unknown magnetospheric mechanisms are at play."

The team reached this finding by examining data from ground-based imagers in the US and Canada and from the electron detector on Arase, a Japanese satellite studying a radiation belt in Earth's inner magnetosphere. The data was taken from 15 September 2017 when Arase was at about 30,000 kilometers altitude and located within a thin active auroral arc for several minutes. The team was able to measure upward and downward movements of electrons and protons, ultimately finding the acceleration region of electrons began above the satellite and extended below it.

To further investigate this so-called very high-altitude acceleration region, the team next aims to analyze data from multiple aurora events, compare high-altitude and low-altitude observations, and conduct numerical simulations of electric potential.

"Understanding how this electric field forms will fill in gaps for understanding aurora emission and electron transport on Earth and other planets, including Jupiter and Saturn," Imajo says.

More information: Shun Imajo et al. Active auroral arc powered by accelerated electrons from very high altitudes, *Scientific Reports* (2021). DOI: 10.1038/s41598-020-79665-5

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