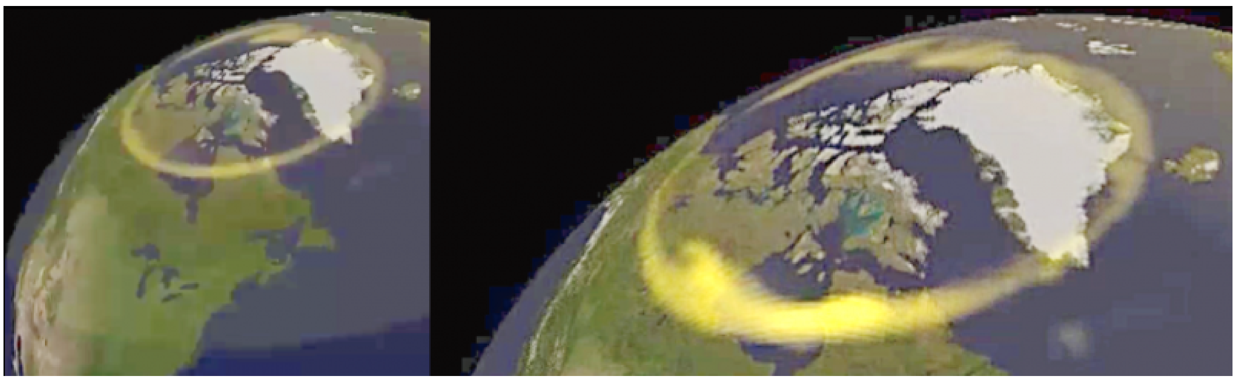
Auroral mystery solved: Sudden bursts caused by swirling charged particles

December 21 2015



On the left is and aurora oval before the auroral breakup occursOn the right is a supercomputer simulation reveals how auroral breakups developHot charged particles, or plasmas, gather in near-Earth space -- just above the upper atmosphere of the polar region -- when magnetic field lines reconnect in space. This makes the plasma rotate, creating a sudden electrical current above the polar regions. Furthermore, an electric current overflows near the bright aurora in the upper atmosphere, making the plasma rotate and discharge the extra electricity. This gives rise to the 'surge', the very bright sparks of light that characterize substorms. Credit: Kyoto University

Auroras are dimly present throughout the night in polar regions, but sometimes these lights explode in brightness. Now Japanese scientists have unlocked the mystery behind this spectacle, known as auroral breakup.

For years, scientists have contemplated what triggers the formation of auroral substorms and the sudden bursts of brightness. Appearing in the *Journal of Geophysical Research*, the current study overthrows existing theories about the mechanism behind this phenomenon.

The Kyoto-Kyushu research team has revealed that hot charged particles, or plasmas, gather in near-Earth space—just above the upper atmosphere of the polar region—when magnetic field lines reconnect in space. This makes the plasma rotate, creating a sudden electrical current above the polar regions. Furthermore, an electric current overflows near the bright aurora in the upper atmosphere, making the plasma rotate and discharge the extra electricity. This gives rise to the "surge", the very bright sparks of light that characterize substorms.

"This isn't like anything that us space physicists had in mind," said study author Yusuke Ebihara of Kyoto University.

Ebihara based the study on a supercomputer simulation program developed by Takashi Tanaka, professor emeritus at Kyushu University.

Auroras originate from plasma from the sun, known as the solar wind. In the 1970s, scientists discovered that when this plasma approaches the Earth together with magnetic fields, it triggers a change in the Earth's magnetic field lines on the dayside, and then on the night side. This information alone couldn't explain how the fluttering lights emerge in the sky, however.

Scientists had come up with theories for separate parts of the process. Some suggested that acceleration of plasma from the reconnection of magnetic field lines caused auroral breakup. Others argued that the electrical current running near the Earth diverts a part of the electrical current into the ionosphere for some unknown reason, triggering the bright bursts of light. This theory was widely accepted because it offered an explanation for why upward-flowing currents emerged out of our planet. But the pieces of the puzzle didn't quite fit well together.

Tanaka's supercomputer simulation program, on the other hand, offers a logical explanation from start to finish.

"Previous theories tried to explain individual mechanisms like the reconnection of the magnetic field lines and the diversion of electrical currents, but there were contradictions when trying to explain the phenomena in its entirety," said Ebihara. "What we needed all along was to look at the bigger picture."

The current paper builds on earlier work by Ebihara and Tanaka about how the bursts emerge. This explores the succeeding processes, namely how the process expands into a large scale breakup.

The research also has the potential to alleviate hazardous problems associated with auroral breakups that can seriously disrupt satellites and power grids.

More information: Y. Ebihara et al. Substorm simulation: Formation of westward traveling surge, *Journal of Geophysical Research: Space Physics* (2015). DOI: 10.1002/2015JA021697

Provided by Kyoto University