PRESS RELEASE

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IMMEDIATE RELEASE June 7, 2021

MEASURING THE PHYSICS OF AURORAL ELECTRON ACCELERATION IN THE LABORATORY

Los Angeles, Ca. June 7, 2021

The shimmering displays of the aurora borealis have always fascinated humankind, first inspiring both awe and fear for their seemingly mysterious origin but more recently capturing the attention of scientists curious to explain what causes this natural phenomenon. Discrete auroral arcs, the most widely known type of aurora, appear as bright and undulating curtains of light. One of the proposed theories to explain the discrete auroral arcs suggests that powerful magnetic waves called Alfvén waves accelerate electrons traveling down along Earth's magnetic field, which then collide with oxygen and nitrogen molecules in the thin air of the upper atmosphere and cause the molecules to emit auroral light. However, a real-world demonstration of how auroral electrons are accelerated down towards the Earth has remained elusive until now.

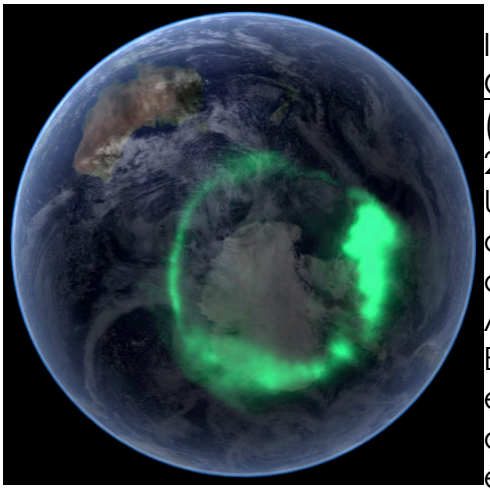

Figure 1: Aurora Australis (southern lights), where a ring of auroral light encircles the Earth's south pole. Credit: NASA Goddard Space Flight

In a recent article published in the journal Nature Communications (https://www.nature.com/articles/s41467-021-23377-5), a team of researchers from the University of Iowa, Wheaton College (IL), UCLA, and the Space Science Institute have demonstrated the acceleration of electrons by Alfvén waves under conditions corresponding to Earth's auroral magnetosphere using laboratory experiments on the Large Plasma Device (LAPD) at UCLA's Basic Plasma Science Facility. The electrons were shown to "surf" on the electric field of the Alfvén wave, a phenomenon known as Landau damping, in which the energy of the wave is transferred to the accelerated electrons, analogous to a surfer catching a wave and being continually accelerated as the surfer moves along with the wave. Numerical computer simulations and mathematical modeling showed clear agreement

with the signature of electron acceleration measured in the laboratory, confirming the first direct experimental demonstration that Alfvén waves can produce accelerated electrons that cause the aurora.

Dr. Jim Schroeder of Wheaton College, first author of the work, said, "For a long time, the start of the auroral process with violent activity at the Sun and the end, with electrons crashing into the upper atmosphere to give off light, have been known. What has remained unknown are the steps in between. This finding supplies an important piece of the puzzle…. Understanding the physics of near-Earth space is practical, too. Our society has become dependent on this region of space, heavily populated with satellites, for communication and navigation, and the dynamics of geomagnetic storms and the aurora can adversely impact those satellites."

"This work brings together the cutting-edge in both laboratory experiments and theoretical techniques," said SSI Research Scientist Dr. Seth Dorfman, a co-author on the paper. "By mastering both the experiment and the theory, [first author] Jim [Schroeder] was able to clearly show that the signature from the lab observations corresponds to electron acceleration by Alfvén waves." Dr. Dorfman helped the team perform the LAPD experiments in his prior position as a postdoctoral fellow at UCLA.

The principal investigator of the primary National Science Foundation/Department of Energy project grant, Dr. Gregory Howes from University of Iowa, noted, "Showing how electrons surf on Alfvén waves above the aurora in the laboratory would not have been possible without bringing together the expertise of scientists that design and perform laboratory experiments, others that build instruments for spacecraft and measure the dynamics of the aurora in space, and still others that devise new theories on how to measure the acceleration of the electrons in space. In addition to resolving a long-standing scientific question about one of the causes of the aurora, the funding for this project has also supported the training of six young scientists who have all gone on to professional careers as faculty members and research scientists at universities and research institutes."

For more information on this project, please refer to https://homepage.physics.uiowa.edu/~ghowes/research/aurora.html

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The paper "Laboratory measurements of the physics of auroral electron acceleration by Alfvén waves" is based upon work supported by the U.S. Department of Energy grant DE-SC0014599, National Science Foundation grants AGS-1054061 and GRF-1048957, and NASA grant 80NSSC18K1217. The Basic Plasma Science Facility (BaPSF) at UCLA is supported by grants through the National Science Foundation (PHY-1561912) and the Department of Energy (DE-FC02-07ER54918). Dr. Dorfman acknowledges prior support from the U.S. Department of Energy Fusion Energy Sciences Postdoctoral Fellowship and NASA Jack Eddy Postdoctoral Fellowship, and current support from NASA award 80NSSC18K1235 to Space Science Institute. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of SSI, University of Iowa, Wheaton College, UCLA, the National Aeronautics and Space Administration, the National Science Foundation, or the US Department of Energy.