A Rock in the Stream

Research team awarded nearly $1.5M in NASA grants

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(Photo by NASA)

By: Becky St. Clair

This week, Jay Johnson, professor of engineering at Andrews University, received word that two grant proposals for research on which he is co-investigator have been selected by NASA. The two grants together total nearly $1.5 million and will fund two separate but related research projects.

The first grant is for a research project studying how fast-flow events bring energy stored in the tail of the magnetosphere toward earth and how the flow of energy ultimately accelerates electrons and ions near the earth. The principal investigator for this grant is Yu Lin, professor of physics at Auburn University (Alabama).

“This project will investigate how the fast flows excite kinetic or small-scale waves that carry energy along the field lines to the ionosphere,” says Johnson. “These waves can lead to electron precipitation (responsible for the Aurora Borealis/Australis) and ion outflows from the ionosphere.”

When the solar wind blows toward the earth, it pushes against the magnetosphere around the planet, stretching it up to 400,000 miles out on the dark side of the earth, creating what is called the magnetotail. Solar wind particles leak into the magnetosphere and are stored in the magnetotail. Dynamical events in the magnetotail, such as reconnection, can release

tubes of particles that slingshot towards the earth at high speed. These fast flows bring energy to the inner magnetosphere, where they suddenly slow down and launch waves, which propagate towards the ionosphere. The waves can heat ions leading to a buildup of the ring current. The energetic particles brought from the magnetotail can also energize radiation belt electrons through complex wave-particle interactions.

The second grant is for a research project studying leakage of solar wind particles across the magnetospheric boundary into the magnetosphere. This leakage is caused by collisions between particles and small-scale waves. The principal investigator for this grant is Katariina Nykyri, professor of physics at Embry-Riddle Aeronautical University (Daytona Beach, Florida).

“The magnetosphere around Earth creates sort of a ‘rock’ in the stream of the solar wind,” Johnson explains. “The magnetosphere is not really moving compared with the solar wind, so you get an instability that develops in the boundary. The boundary starts getting wavy and develops into curls.”

We have all experienced this type of instability when we see waves develop when there is wind over water. To demonstrate the principle, Johnson holds a piece of notebook paper between his index finger and thumb, blowing on the edge of the paper. The paper quickly wiggles into waves, and is lifted by the “wind” blowing over it.

“The instabilities cascade to small scales on the size of the orbit of the particles,” Johnson continues. “As the ions encounter the magnetic field structures they scatter, and this turbulence allows particles to leak into the magnetosphere from the solar wind.”

Johnson is working to understand the nature of this interaction between the solar wind and the boundary of the magnetosphere. This work is important because it determines how energy is transferred from the solar wind to the magnetosphere, driving the latter’s dynamics. Ultimately, the transferred energy affects the radiation belts inside the magnetosphere, which in turn can have an effect on any satellites in the vicinity.

“The belts change dramatically,” Johnson says. “People in my field are interested in understanding when the fluxes increase and what causes them to change so dramatically.”

And why is NASA interested in this? Because fluctuations in the outer radiation belt can be a danger to satellites.

Between Earth and the sun is a satellite run by NOAA, which scientists use to monitor activity on the sun. This allows for a 30-minute warning if anything is coming toward the Earth. Researchers like Johnson are looking to find a way to predict events ahead of those 30 minutes so necessary measures can be taken to mitigate damage to any assets nearby.

Johnson recalls that in 2012, a major event took place on the sun that hit a couple of satellites monitoring for such things.

“If that event had gone toward Earth instead of in the direction where the satellites happened to be, we would have been in a lot of trouble,” he says. “It could have knocked out major power grids and satellite communications, among other things. The idea is to understand more of what’s happening out there and how it affects our magnetosphere so we can predict the probability of events like that coming this direction.”

The two research teams will begin their research with these three-year NASA grants in fall 2017. Johnson will be working with colleagues across the country at institutions such as University of Alaska, Princeton (New Jersey) and University of California-Los Angeles. He also has four Andrews University students working with him on the research; two in physics and two in engineering.

“It’s exciting to be able to do this research,” says Johnson, who has a long history of receiving research funds from NASA. He is currently the principal investigator on two other NASA grant research projects and co-investigator on several others.

Johnson is the newest member of the engineering faculty, beginning his tenure at Andrews in fall 2016. Prior to accepting the position at Andrews, Johnson worked in the Princeton Plasma Physics Laboratory, where he led the space physics group for the past 11 years—a group he quadrupled in size during his leadership through a successful flow of external funding.

In 1987, Johnson graduated with a degree in physics from University of Colorado-Boulder, with distinction. In 1992 he completed a PhD in physics at Massachusetts Institute of Technology (MIT; Cambridge, Massachusetts).

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