New data on radiation show missions to Jupiter's moon Europa are possible

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This artist concept depicts the Juno spacecraft which arrived at Jupiter in 2016 after a five-year journey to study the giant planet. Credit: NASA Jet Propulsion Laboratory, JPL

Scientists from NASA's Juno mission have developed the first complete 3D radiation map of the Jupiter system, including characterizing the intensity of the high-energy particles near the orbit of the icy moon Europa, and how the radiation environment is sculpted by the smaller

Jovian moons orbiting near Jupiter's rings.

The work relies on data collected by Juno's star camera Advanced Stellar Compass (ASC) designed and built by Technical University of Denmark, and Stellar Reference Unit (SRU), which was built by Leonardo, S.p.A. in Florence, Italy. The two datasets complement one another, helping Juno scientists characterize the radiation environment at different energies.

Both ASC and SRU are low-light cameras designed to assist in the challenges of deep-space navigation. These types of instruments are on almost all interplanetary and Earth-orbiting spacecraft. To get them to operate as radiation detectors, the Juno science team had to look at the cameras in a whole new light.

"On Juno we try to innovate new ways to use our sensors to learn about nature and have used many of our science instruments in ways they were not designed for," said Scott Bolton, Juno principal investigator from the Southwest Research Institute in San Antonio.

"This is the first detailed radiation map of the region at these higher energies, which is a major step in understanding how Jupiter's radiation environment works. That we've been able to create the first detailed map of the region is a big deal, because we don't carry an instrument designed to look for radiation. The map will help in planning observations for the next generation of missions to the Jovian system," says Bolton.

Counting fireflies

Juno's ASC star camera images of stars to determine the spacecraft's orientation in space, which is vital to the success of the spacecraft's MAG experiment. But the four star cameras—located on Juno's magnetometer boom—have also proved to be valuable detectors of high-energy particle fluxes in Jupiter's magnetosphere. They record "hard radiation"—ionizing radiation of high-penetrating power that impacts a spacecraft with sufficient energy to pass through the ASC star camera's shielding.

"Every quarter-second the ASC takes an image of the stars," said Juno scientist John Leif Jørgensen, professor at the Technical University of Denmark.

"Very energetic electrons that penetrate its shielding leave a telltale signature in our images that looks like the trail of a firefly. The instrument is programmed to count the number of these fireflies, giving us an accurate calculation of the amount of radiation," says Jørgensen.

Because of Juno's ever-changing orbit, the spacecraft has traversed practically all regions of space near Jupiter.

ASC data from the star camera suggest that there is more very high energy radiation relative to lower energy radiation near the moon Europa's orbit than previously thought. The data also confirms that the amount of high energy electrons present on the side of Europa facing into its orbital direction of motion is greater than the moon's slipstream.

This is due to the fact that most of the electrons in Jupiter's magnetosphere overtake Europa from behind due to Jupiter and its magnetic field rotation, but the very high energy electrons drift backwards, almost like fish swimming upstream, and they slam into Europa's leading side.

The radiation data from the Jupiter system is not the first unplanned scientific contribution ASC has made to the mission. Even before arriving at Jupiter, ASC data was used to measure the interplanetary dust impacting Juno. And the imager even discovered a previously uncharted comet using the same dust detection technique—distinguishing small bits of the spacecraft ejected by microscopic dust impacting Juno at very high velocity.

The results from the Juno mission are in the final round of peer review and will be published in the journal *Geophysical Research Letters*.

Dust rings

Like the ASC the SRU has been utilized as a radiation detector and a low light imager.

Data from Juno's SRU and ASC indicate that, like Europa, the small "shepherd moons" that orbit within or close to the edge of Jupiter's rings (and help to hold their shape) also appear to interact with Jupiter's radiation environment. When the spacecraft flies on magnetic field lines connected to ring moons or dense dust, the radiation count on both ASC and SRU dropped precipitously. The SRU is also collecting rare low light images of the rings from Juno's unique vantage point.

"There is still a lot of mystery about how Jupiter's rings were formed, and very few images have been collected by prior spacecraft," said Heidi Becker, lead co-investigator for the SRU and a scientist at NASA's Jet Propulsion Laboratory, which manages the mission.

"Sometimes we're lucky and one of the small shepherd moons can be captured in the shot. These images allow us to learn more precisely where the ring moons are currently located and see the distribution of dust relative to its distance from Jupiter."

Provided by Technical University of Denmark

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