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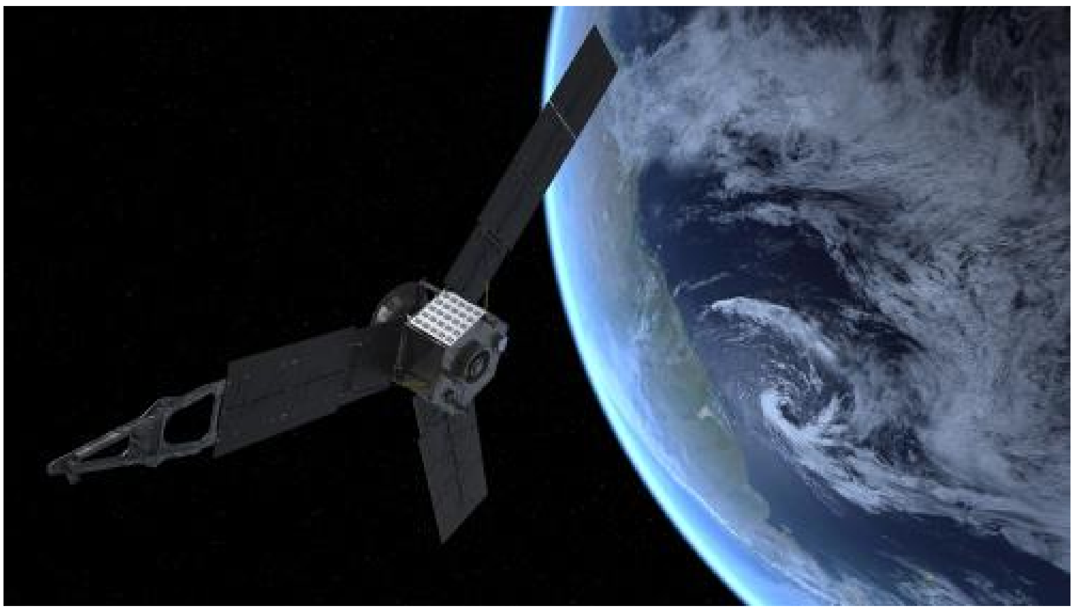
Juno mission scientists discuss Jupiter's mysteries

July 8 2016, by Lori Dajose



Credit: Southwest Research Institute

After nearly five years and 1.8 billion miles of space travel, NASA's Juno mission will arrive at Jupiter on July 4, 2016. Managed by NASA's Jet Propulsion Laboratory, the spacecraft will orbit Jupiter for 20 months, completing 37 orbits, and will then spiral down into the planet at the end of its mission in 2018. Three Caltech professors—Andrew Ingersoll, professor of planetary science; Dave Stevenson, Marvin L. Goldberger Professor of Planetary Science; and Ed Stone, David Morrisroe Professor of Physics and vice provost for special projects—are on the mission team. None are strangers to the giant planets—collectively, they have more than 100 years of experience studying the outer solar system. We spoke with them about Jupiter, the Juno mission, and the future of solar system exploration.

What is your specific role on the Juno mission?

Dave Stevenson: I lead the interiors working group, which has responsibility for interpreting the Juno data that tell us what is going on inside Jupiter: Does it have a core? What does the structure of Jupiter tell us about how it formed? Where is the magnetic field produced? How far down do the strong winds extend? The relevant measurements Juno makes are the gravity field, magnetic field, and water content.

Andrew Ingersoll: I am the head of the atmospheres working group and a member of two instrument teams—for the microwave radiometer (MWR) and the camera (JunoCam).

Ed Stone: I am a senior advisor for science and management.

What is special about Jupiter? What scientific questions are you hoping to answer with Juno?

DS: Jupiter makes up most of the planetary mass in our solar system. It probably formed before the other planets and controlled the architecture of our planetary system through its gravity. The way in which it formed will help us understand how planets in general form. And last but not least, it may even have controlled the delivery of water to Earth and thus affected the environment of our home planet.

AI: Jupiter is the largest planet and it comes closest to having the same proportion of chemical elements (hydrogen, helium, oxygen, carbon, nitrogen, sulfur, etcetera) as the sun. Also, it is like a fluid dynamics laboratory where storms last for decades and the planet's rotation steers the winds into multiple jet streams.

With Juno, we would like to determine the average water abundance of the deep atmosphere. This question bears on the oxygen-to-hydrogen ratio on Jupiter compared to the ratio on the sun. The ratio is fundamental to how the elements were distributed through the early solar system and how Earth got its oceans. Additionally, we are trying to map how water and ammonia vary with latitude. This question bears on the weather below the visible clouds—a region we know little about. Jupiter has a very photogenic atmosphere, so we know a lot about the weather at the tops of the clouds. The unique phenomena there may derive their properties from the weather at deeper levels.

ES: Jupiter's magnetosphere—the region occupied by Jupiter's magnetic field—is the largest object in the solar system. Its radius is larger than the sun! The magnetic field is responsible for Jupiter's aurorae—glowing regions in the north and south polar regions caused by ions and electrons spiraling down along the magnetic field lines. Juno's orbit will be north-to-south, taking it over the poles and through the aurorae. We are interested in details about the aurorae—what kinds of particles are spiraling down into the atmosphere? What is the up-close structure of this huge magnetic field?

What other missions have you worked on? How do they compare?

DS: I'm also involved in Cassini, which has been spectacularly successful, especially for the satellites of Saturn, less so for Saturn itself. But in the coming year or so, Cassini will do some of the same things for Saturn that Juno will do for Jupiter by orbiting inside the rings and obtaining very precise gravity and magnetic-field data.

ES: I am the project scientist for Voyager 1 and Voyager 2, both of which conducted a flyby of Jupiter. They made videos of the winds, flew near the largest moons, determined the large-scale structure of the magnetosphere, and observed the aurorae from a distance. Juno is in a distinctly different orbit, and its electronics are protected from radiation so it can get closer to the planet. The Galileo mission was able to closely study the moons, but it was in an equatorial orbit. Juno is probing the inner frontier of the Jovian system and we expect many discoveries.

AI: I have worked on every mission to the giant planets—the Pioneers, Voyagers, Galileo, Cassini, and now Juno. I am amazed at the richness of the outer solar system. It seems that every time we go there with new instruments or visit a new part of it, we discover things that surprise us—things that our Earth-centric science couldn't predict.

What is the future of giant planet exploration?

DS: Even though Cassini may be a success for Saturn, it will not answer one of the key questions that Juno should answer for Jupiter: How much water is there? For Saturn, that will probably require a probe—like the Galileo probe but going deeper into the atmosphere. A mission to an ice giant (Uranus or Neptune) is perhaps even more important and is high on the priority list for NASA. These kinds of planets are now known to be common in the universe and we know remarkably little about what goes on inside them.

AI: The immediate focus is on Jupiter and its moon Europa. The European Space Agency has the Jupiter Icy Moons Explorer (JUICE) and NASA has the Europa Orbiter. After that, Enceladus and Titan—two of Saturn's moons—will be ripe for intensive exploration. The common theme is liquid water beneath the icy crusts of these outer planet satellites. With organic compounds and chemical energy sources, the icy moons extend the range of habitability outward from Earth orbit. That doesn't mean they are inhabited, but means that many of the necessary conditions for life are present.

ES: The next major NASA mission will be to Jupiter and its moon Europa. We know from Galileo that there is a liquid water ocean beneath its icy crust. We know that on Earth, wherever there's liquid water, there's microbial life. Europa is certainly a place we want to explore.

Provided by California Institute of Technology

Citation: Juno mission scientists discuss Jupiter's mysteries (2016, July 8) retrieved 27 April 2024 from https://phys.org/news/2016-07-juno-mission-scientists-discuss-jupiter.html