



מכון ויצמן למדע

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Science *Tips*

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Jupiter, Revealed: Israeli Scientists Peer Beneath the Cloud Cover of Our Solar System's Largest Planet

More than 400 years after Galileo turned his telescope toward the planet Jupiter, the clouds and mist covering this giant of the Solar System are beginning to disperse. Since 1973, no fewer than six spacecraft have flown by Jupiter. But the Juno probe, launched in 2011 and in orbit around the planet since July 2016, is the first one equipped with systems that are able to reveal the secrets of Jupiter's inner structure beneath the thick clouds. Two scientists from the Weizmann Institute of Science, Dr. Yohai Kaspi of the Earth and Planetary Sciences Department and his research partner, Staff Scientist Dr. Eli Galanti, are part of the Juno team that includes 40 scientists from around the world. Kaspi and Galanti are leading one of the space mission's main experiments, aimed at learning how deep the planet's characteristic strong jet currents go and at understanding the structure of the planet's gravitational field. Juno's initial findings were recently published in the journal *Science*, in an article based on 44 research papers that explore the planet in detail and which were simultaneously published in *Geophysical Research Letters*. Kaspi explains: "These articles relate preliminary results. It was important for us, first of all, to report that we have reached Jupiter and that all systems are go – and here are our first, and surprising, readings."

In Roman mythology, Juno is the wife and sister of the god Jupiter. When Jupiter wanted to hide something from her, he enveloped himself in a cloud cover, but Juno pointed a deep gaze, scattering his cover.

Likewise, shortly after the probe Juno began orbiting Jupiter, the planet, almost entirely made up of gas, started to yield its secrets. The main findings so far include cyclones at the planet's poles spanning thousands of miles, a significantly stronger-than-expected magnetic field with great variations in power between regions, and an ammonia belt surrounding the planet's equator. Another significant finding concerns a question scientists were divided over: Does the planet have a solid core, or does it not have a core at all? The data obtained so far shows that both sides were wrong: Jupiter does have a core – an even greater one than expected – but it doesn't seem to be solid.

Achievements aside, the complex space mission has not been glitch-free. Juno was supposed to orbit the planet in 14 days but due to a propulsion system malfunction, the route was extended, taking 53.5 days instead. Nevertheless, Juno still orbited the planet – as planned – in an elliptical route that allowed it to approach up to 4,000 kilometers above the planet's cloud peaks – coming closer to Jupiter than any spacecraft ever has. Despite this malfunction and the fact that the spacecraft will now have to continue in orbit around Jupiter for a total of three more years, the Weizmann scientists admit that the added time in orbit provides some "breathing space" and an opportunity to plan the experiments better. Even the measurement angles have improved: "Our experiment," explains Kaspi, "uses changes in Jupiter's gravitational field to measure gas movement on the planet."



(l-r) Drs. Yohai Kaspi and Eli Galanti are leading one of NASA's main Juno space mission experiments

The measurements are conducted through the means of a Doppler shift of a radio wave transmitted from the probe; the change in orbit due to the malfunction allows us to make more accurate measurements."

In a press conference held by NASA to report the initial findings, Juno mission principal investigator Scott Bolton said: "We're seeing a lot of our ideas were incorrect and maybe

naïve.” This far-reaching statement made headlines around the world, but Galanti believes it was not properly understood: “When Bolton said we were naïve, he meant that in many ways, our expectation was to find a much simpler reality than the one

we ultimately found. For example, with regards to the magnetic field, we expected a homogenous one, and not, as we learned, one that drastically changes from point to point. While this discovery ‘makes things more complicated,’ it does not pull the rug

from under our feet. On the contrary, it allows us to sharpen the existing models.” **I**

Dr. Yohai Kaspi’s research is supported by the André Deloro Institute for Space and Optics Research.

<http://science.sciencemag.org/content/356/6340/821>

Jerusalem Tower Younger than Thought

Ultra-precise dating takes nearly 1,000 years off its age

Gihon Spring, just downhill from the ancient city of Jerusalem, was crucial to the survival of its inhabitants, and archaeologists had uncovered the remains of a massive stone tower built to guard this vital water supply. Based on pottery and other regional findings, the archaeologists had originally assigned it a date of 1,700 BCE. But new research conducted at the Weizmann Institute of Science provides conclusive evidence that the stones at the base of the tower were laid nearly 1,000 years later. Among other things, the new results highlight the contribution of advanced scientific dating methods to understanding the history of the region.

Dr. Elisabetta Boaretto, Head of the Weizmann Institute of Science’s D-REAMS Radiocarbon Dating Laboratory and track leader within the Max Planck-Weizmann Center for Integrative Archaeology and Anthropology, had the opportunity to date the tower as part of her ongoing cooperative research projects with the Israel Antiquity Authority (IAA). Since 2012, Dr. Joe Uziel and Nahshon Szanton of the IAA, in continuing the excavations around the tower, have discovered that the base of the tower was not built on bedrock. “The boulders in the tower’s base, in and of themselves,” explains Boaretto, “do not yield any information other than the fact that whoever placed them there had the ability to maneuver such heavy stones. But underneath the boulders, the soil exhibits the layers typical of archaeological strata, and these can reveal the latest date that the site was occupied before the tower was built.”

The unique and methodical approach of the D-REAMS lab team begins by planning and executing the field sampling and excavation from the beginning – together with the site archaeologists. “Getting one’s hands dirty is all part of building a reliable chronology,” says Boaretto. During

field work conducted with the archaeologists and later in her laboratory with postdoctoral fellow Dr. Johanna Regev, Boaretto identified several clearly-delineated strata. From these, they carefully collected remains of charcoal, seeds and bones – organic matter that can be definitively dated through radiocarbon dating.

The first dating was conducted on mid-to-lower levels of sediment, and these dates indeed agreed with those originally proposed. “But there was another half-meter of sediment between the material we had dated and the large cornerstone,” says Boaretto. “At a glance, we thought this might represent another few hundred years before the stone was placed.” The presence of separate, sequential layers, which they identified using microarchaeological tools and radiocarbon dating, enabled the researchers to attach dates to the strata just below the tower.

The radiocarbon dating method is based on counting the radioactive ^{14}C atoms in a sample. These carbon atoms are found in all living things in a small, but stable ratio to that of regular carbon, and they begin to decay at a known rate after death. At the Weizmann Institute of Science, the count of ^{14}C atoms in a sample is performed with an accelerator, so it can return highly accurate results on something as small as a seed.

The date revealed by this radiocarbon dating was sometime around 800-900 BCE. That is nearly 1,000 years later than thought, and it moves the building of the tower to another historical period entirely, from the Middle Bronze Age to the Iron Age.

To complete the study, Boaretto and her team asked whether any explanation could allow the tower to have been built earlier – repairs, for example – but the presence of the large boulders sitting above layers of earth containing the remains of

everyday activities would appear to be fairly conclusive evidence that the later date is the correct one. Boaretto: “The conclusive, scientific dating of this massive tower, placing it in a later era than was presumed, will have repercussions for other attempts to date construction and occupation in ancient Jerusalem.” **I**

Dr. Elisabetta Boaretto’s research is supported by the Dangoor Accelerator Mass Spectrometer Laboratory.



Recently uncovered remains of a massive stone tower built to guard Gihon Spring – a vital water supply just downhill from the ancient city of Jerusalem