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WEIZMANN INSTITUTE OF SCIENCE

Science Tips

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Israeli Eyes on Jupiter Orbiter

Dr. Yohai Kaspi is part of the Juno Science team that hopes to answer some burning questions about the largest planet in the Solar System

On July 4, NASA's Juno spacecraft will be entering orbit around Jupiter, the largest planet in the Solar System. Its extended trip – more than 2 billion kilometers over nearly five years – will be over, but its work will just be beginning. Following some intricate maneuvers, the spacecraft will go into a unique 14-day orbit that will allow it to get as close as 4000 km above the cloud tops of the planet – much closer than any mission ever before flown.

"We will have an opportunity to study the flows beneath the thick clouds we see covering Jupiter"

Image: NASA

When Juno enters orbit, the Weizmann Institute's Dr. Yohai Kaspi will be ready. "For the first time," he explains, "we will have an opportunity to study the flows beneath the thick clouds we see covering Jupiter." Kaspi, who is part of the Juno Science team, and Institute staff scientist Dr. Eli Galanti, will be at the Jet Propulsion Laboratory in Pasadena, California, along with the other scientists and engineers on the Juno team, to witness the event. Juno is already within the gravitational sphere of Jupiter, and the team will be holding their breath as the speeding spacecraft aligns itself into a stable orbit and begins sending data. The research team has planned an eccentric circuit for the ship, so that it can swing in closely to observe and measure and then circle farther out to preserve its orbit.

Among the many questions Kaspi, Galanti and their colleagues would like to answer is this: How deep are the weather patterns we observe on Jupiter's surface? These patterns are gas flows that appear as ordered stripes on the planet's outer surface, and because there is no solid ground to disrupt them, they may extend very deep into the interior. Adding the third dimension to our understanding of these patterns could help to answer any number of other questions, including how do these patterns form, whether the outer layers rotate in sync with the inner ones, how thick is the famous Great Red Spot, and

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<<< whether the planet has a solid inner core, which is key for understanding how planets form.

Kaspi, who has been with the Juno project nearly a decade, has used the interval to work out the tools for analyzing measurements that will be taken of the planet's gravity. Since weather – the movement of mass around the planet – creates slight variations in the planet's gravity at different points, Kaspi and his team will use the data from Juno's measurements of the gravitational fields to "reverse calculate" the wind patterns that modified them.

In this way, he will help scientists "peer for the first time beneath the thick cloud layer" of Jupiter. Kaspi has already applied these tools to calculating the depth of weather patterns on Uranus and Neptune, showing that the high winds on these planets are confined to a relatively shallow upper layer, as well as to analyzing measurements of Jupiter and Saturn obtained from Earth- bound telescopes. But the Juno mission will provide the first opportunity to measure the differences in Jupiter's gravitational fields precisely and accurately, and thus develop a clearer picture of the planet's interior and atmospheric dynamics.

Dr. Yohai Kaspi's research is supported by the Helen Kimmel Center for Planetary Science.

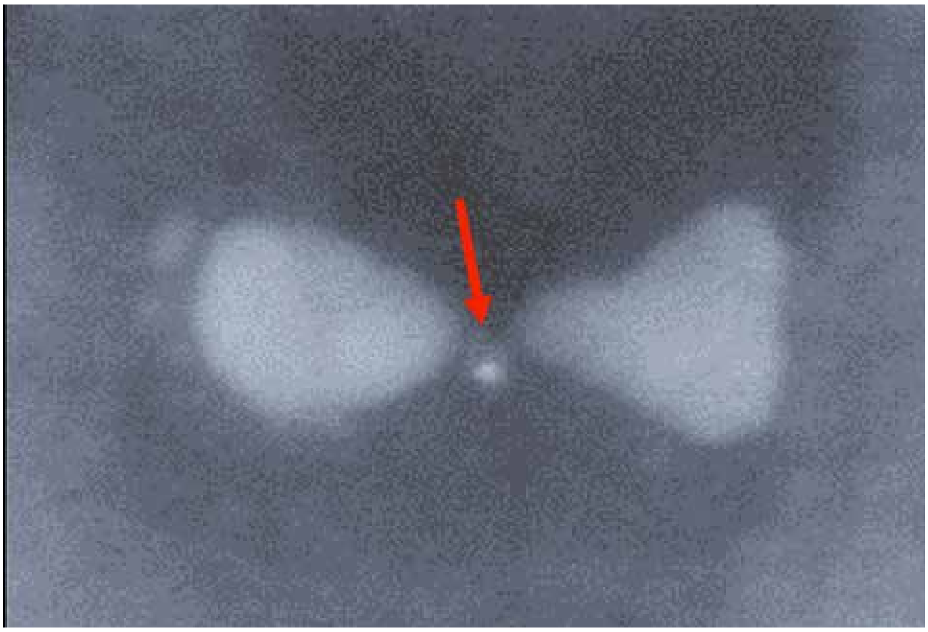
https://www.missionjuno.swri.edu/

Building a Better Bowtie

Bowtie-shaped nanostructures may advance the development of quantum devices

Bowtie-shaped nanoparticles made of silver may help bring the dream of quantum computing and quantum information processing closer to reality. These nanostructures, created at the Weizmann Institute of Science and described recently in *Nature Communications*, greatly simplify the experimental conditions for studying quantum phenomena and may one day be developed into crucial components of quantum devices.

The research team led by Prof. Gilad Haran of Weizmann's Chemical Physics Department – postdoctoral fellow Dr. Kotni Santhosh, Dr. Ora Bitton of Chemical Research Support and Prof. Lev Chuntonov of the Technion–Israel Institute of Technology – manufactured two-dimensional bowtie-shaped silver nanoparticles with a minuscule gap of about 20 nanometers (billionths of a meter) in the center. The researchers then dipped the "bowties" in a solution containing quantum dots, tiny semiconductor particles that can absorb and emit light, each measuring six to eight nanometers across. In the course of the dipping, some of the quantum dots became trapped in the bowtie gaps.



A bowtie-shaped nanoparticle made of silver with a trapped semiconductor quantum dot (indicated by the red arrow)

Under exposure to light, the trapped dots became "coupled" with the bowties – a scientific term referring to the formation of a mixed state, in which a photon in the bowtie is shared, so to speak, with the quantum dot. The coupling was sufficiently strong to be observed even when the gaps contained a single quantum dot, as opposed to several. The bowtie nanoparticles could thus be prompted to switch from one state to another: from a state without coupling to quantum dots, before exposure to light, to the mixed state characterized by strong coupling, following such exposure.

Therefore the ability to control the coupling of quantum dots may one day be employed in the manufacture of switches for computing or encryption devices relying on quantum phenomena, that is, those operating at the level of photons and single quantum systems, such as atoms, molecules or quantum dots. Because such phenomena open up possibilities unavailable on the macroscopic scale – for example, performing multiple computations simultaneously – quantum devices are expected to be vastly more powerful than today's electronic computers and encryption systems.

Says Prof. Haran: "We've made a first step toward creating quantum switches using our coupling method. Much research needs to be done before the method can be incorporated into actual devices, but as a matter of principle, our system is relatively easy to generate and, most importantly, can function at room temperature. We are currently working to fabricate even smaller bowtie particles and to render the coupling stronger and reversible."

The Weizmann scientists managed to design their bowtie system thanks to advances in nanotechnology – including electron beam >>>

>>> lithography, used to fabricate the bowties and to facilitate the introduction of quantum dots into their gaps – and the advent of computational programs providing data analysis that previously required a massive effort on the part of theoreticians. They also relied on the recently improved understanding of electron oscillations triggered by light in metals, which constitute the physical source of the coupling between the bowtie nanoparticles and the quantum dots: Such oscillations are known to be strongest on the metal surface. In the new bowtie-shaped particles, the electromagnetic field generated by these oscillations is extremely concentrated because it is focused to the central, narrow portion of the bowtie, much as light is concentrated when focused into a narrow beam.

The high concentration ensures tight control over the coupling, and this control, in turn, is essential for potential future quantum applications. None of the systems built in the past to study quantum interactions between light and matter operated on such a small scale or were able to reduce experiments to the level of individual quantum dots, as was done in the Weizmann study.

Prof. Gilad Haran's research is supported by the Ilse Katz Institute for Material Sciences and Magnetic Resonance Research, which he heads; the Nancy and Stephen Grand Research Center for Sensors and Security, which he heads; the Henry Chanoch Krenter Institute for Biomedical Imaging and Genomics; the Carolito Stiftung; the Weston Nanophysics Challenge Fund; Mr. and Mrs. Antonio Villalon; and the Prof. Dov and Ziva Rabinovich Foundation. Prof. Haran is the incumbent of the Hilda Pomeraniec Memorial Professorial Chair.

http://www.nature.com/ncomms/2016/160613/ncomms11823/full/ncomms11823.html

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First Class of the Schwartz/Reisman Science Education Centre, Rehovot, Graduates

Caption: Dr. Ronen Mir (center) and the teachers of the Schwartz/Reisman Science Education Centre, Rehovot

The graduation ceremony of the first class of the Schwartz/Reisman Science Education Centre, Rehovot took place on June 29 in the Clore Garden of Science on the Weizmann Institute of Science campus. Participating were Weizmann Institute of Science President Prof. Daniel Zajfman, Rehovot Deputy Mayor Zohar Blum and Ness Ziona Mayor Yossi Shavo. Also present were the 207 twelfth-graders who had completed their final matriculation exam in physics. "When you learn physics," said Prof. Zajfman, "you are learning a way of thinking. Graduates of the Schwartz/Reisman Science Education Centre, Rehovot, can now do anything they desire. Special thanks to the most important people – the teachers," he continued. "Teaching is the only profession that allows all the other professions to exist. Without people who commit themselves to helping our children to build their futures, we would not succeed in attaining ours."

The Schwartz/Reisman Science Education Centre, Rehovot, opened three years ago in the Ruth and Uriel Arnon Science Education Campus, on the Weizmann Institute of Science campus. Its aim is to give high-school students in Rehovot and Ness Ziona the opportunity to learn physics at a higher level. The unique approach of the Centre was first developed at the Weizmann Institute of Science and applied, with great success, in the Hemda Schwartz/Reisman Center in TA. The idea is to create a centralized space for all the students in the area, and then equip it with modern labs and the best possible physics teachers – those who will be continually involved in learning science themselves and updating their teaching methods. The students attend for free, and the center is run jointly by the municipalities of Rehovot and Ness Ziona, and the Weizmann Institute of Science. The graduates attended classes in the Centre twice a week for three years. One measure of its success: The cities of Rehovot and Ness Ziona are already reporting a rise in the number of students sitting for advanced physics and math matriculation exams.

The Center's 15 teachers and three lab directors work full time; in addition to teaching these classes, they are given time to develop new curricula and tests, and to help one another. "We put 15 physics teachers in one room," says Centre Director Dr. Ronen Mir, "and they get really creative – and when they enjoy themselves, the students enjoy too."

The Schwartz/Reisman Science Education Centre, Rehovot, is supported by the Gerald Schwartz and Heather Reisman Foundation; Ruth and Uriel Arnon; Manfred D. Moross; the Windsong Trust; and the Gelfand Family Charitable Fund.

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