UC Irvine scientists discover new state of quantum matter

The research can help make new quantum technologies primed for deep-space travel.
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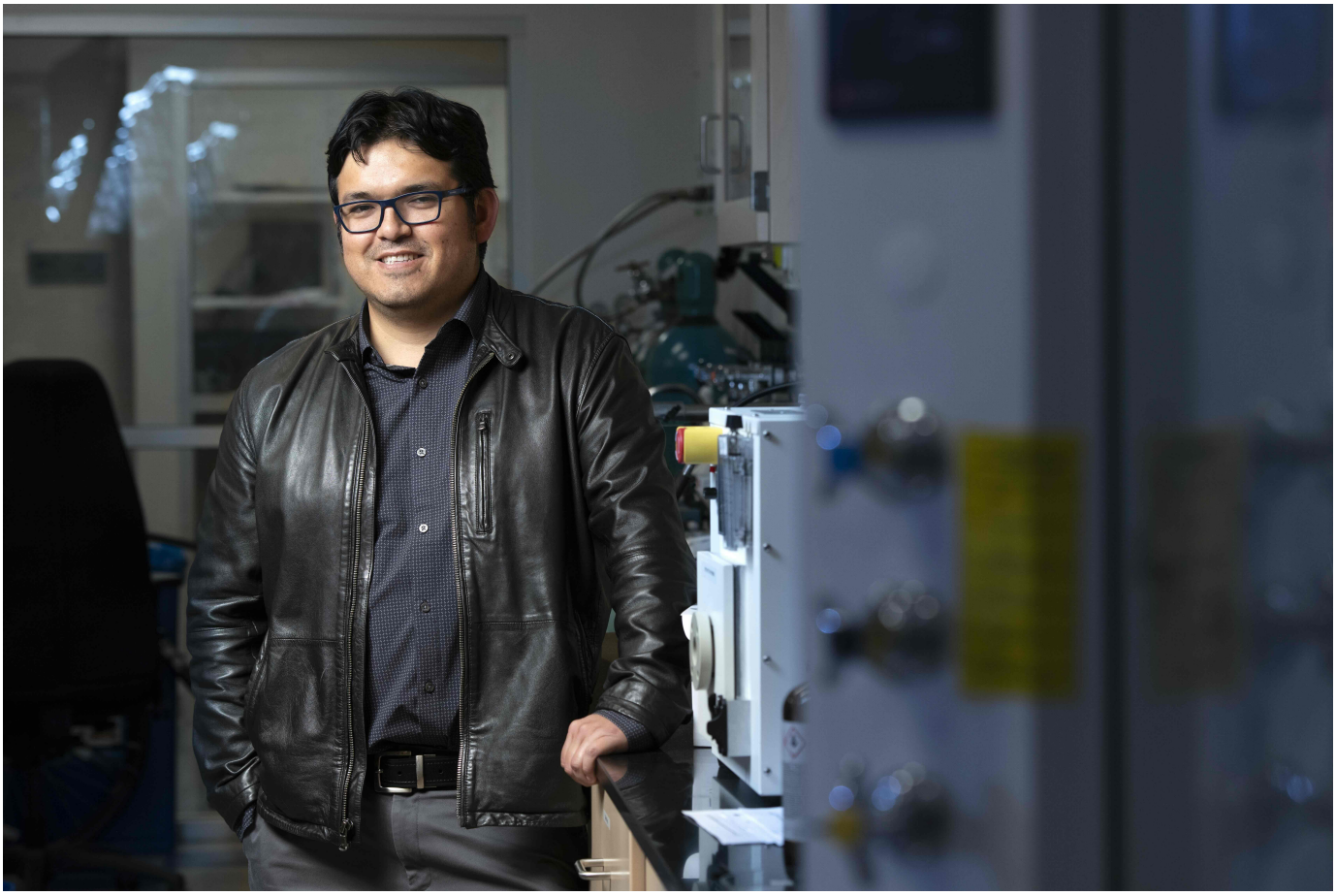

Professor Luis Jauregui of the UC Irvine Department of Physics & Astronomy described how the new material he and his lab developed only exists in their labs.

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Steve Zylius / UC Irvine

- The new state of matter exists only in labs at UC Irvine.

- The material benefits include computers that don’t need to be charged and that are immune to the harmful effects of cosmic radiation.

Irvine, Calif., July 24, 2025 — Researchers at the University of California, Irvine have discovered a new state of quantum matter. The state exists within a material that the team reports could lead to a new era of self-charging computers and ones capable of withstanding the challenges of deep space travel.

“It’s a new phase of matter, similar to how water can exist as liquid, ice or vapor,” said Luis A. Jauregui, professor of physics & astronomy at UC Irvine and corresponding author of the new *Physical Review Letters*. “It’s only been theoretically predicted – no one has ever measured it until now.”

This new phase is like a liquid composed of electrons and their counterparts, known as “holes,” spontaneously pairing and forming exotic states known as excitons. Unusually, the electrons and holes spin together in the same direction. “It’s its own new thing,” Jauregui said. “If we could hold it in our hands, it would glow a bright, high-frequency light.”

The phase exists in a material developed at UC Irvine by Jinyu Liu, a postdoctoral researcher in Jauregui’s lab and the first author of the paper. Jauregui and his team measured the phase using high magnetic fields at the Los Alamos National Laboratory (LANL) in New Mexico.

The key to creating the new quantum matter was in applying a high-intensity magnetic field of up to 70 Teslas to the material (by comparison, the magnetic field from a strong fridge magnet is around 0.1 Teslas), which the team calls hafnium pentatelluride

Jauregui explained that, as his team applied the magnetic field, the “material’s ability to carry electricity suddenly drops, showing that it has transformed into this exotic state,” he said. “This discovery is important because it may allow signals to be carried by spin rather than electrical charge, offering a new path toward energy-efficient technologies like spin-based electronics or quantum devices.”

Unlike conventional materials used in electronics, this new quantum matter isn’t affected by any form of radiation, which makes it an ideal candidate for space travel.

“It could be useful for space missions,” Jauregui said. “If you want computers in space that are going to last, this is one way to make that happen.”

Companies like SpaceX are planning human-piloted space flight to Mars, and to do that effectively, you need computers that can withstand prolonged periods of exposure to radiation.

“We don’t know yet what possibilities will open as a result,” Jauregui said.

The material was synthesized, characterized and made into measurable devices at UC Irvine by Jinyu Liu with assistance from graduate students Robert Welser and Timothy McSorley, and undergraduate researcher Triet Ho. Theoretical modeling and interpretation were provided by Shizeng Lin, Varsha Subramanyan, and Avadh Saxena at LANL. High-magnetic-field experiments were conducted with the support of Laurel Winter and Michael T. Pettes at LANL and David Graf at the National High Magnetic Field Laboratory in Florida.

About UCI’s Brilliant Future campaign: Publicly launched on Oct. 4, 2019, the Brilliant Future campaign aims to raise awareness and support for UCI. By engaging 75,000 alumni and garnering $2 billion in philanthropic investment, UCI seeks to reach new heights of excellence in student success, health and wellness, research and more. The School of Physical Sciences plays a vital role in the success of the campaign. Learn more by visiting https://brilliantfuture.uci.edu/uci-school-of-physical-sciences/.

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