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Bringing quantum mechanics to life | New ISTA professor Julian Léonard makes abstract quantum properties visible

From the realm of the abstract to the tangible, the new assistant professor at the Institute of Science and Technology Austria (ISTA) Julian Léonard brings the quantum properties of matter to life. Having done research at ETH Zurich and Harvard, Léonard joins ISTA from TU Wien. His research plays with the rules of quantum physics like a board game to uncover new quantum phenomena, thus underlining the central role of quantum mechanics in nature..

In material science, states of matter are often regarded from a classical physics perspective, where atoms behave like particles. But physicists are becoming increasingly aware that nothing in nature can exist without quantum mechanics, the realm in which tiny objects behave simultaneously like particles and waves. New Institute of Science and Technology Austria (ISTA) Assistant Professor Julian Léonard and his team find ways to understand how states of matter arise from a purely quantum-mechanical perspective. “This lets us sometimes stumble upon new quantum properties that we could call ‘exotic’. Since nature is quantum mechanical at its heart, we want to push the limits of what quantum states can achieve,” says Léonard.

Visualizing abstract atomic interactions

The quantum world is often perceived as highly abstract. This field of physics is governed by striking correlations such as entanglement, whereby the properties of two particles remain linked regardless of physical separation. According to Léonard, this is where quantum physics manifests at its best. The more entangled a system is, the harder it is for classical physics to account for its properties without quantum mechanics. Thus, Léonard and his group take highly entangled systems as a starting point for uncovering new quantum phenomena.

Quantum properties like entanglement arise at ultracold temperatures, where no other field of physics can detect any movement. These ultracold temperatures magnify the quantum effects from the atomic scale to a scale similar to the size of a cell. For scale, this is as if one person can move an entire mountain. “Many concepts in physics become clearer when built from the bottom up,” says Léonard. “With my group, I work on bringing the quantum realm to life, making it visible. We explore the quantum properties of matter literally before our eyes using an optical microscope and fluorescence.”

Like a board game

Léonard is fascinated by atomic particles and their quantum interactions, which have their own sets of rules. “The beautiful part about the quantum realm is that once scientists understand its rules, they can play with them like in a board game. Things are possible in quantum mechanics that we find hard to imagine in our tangible world,” he explains.

By accepting these rules and learning to play the game, Léonard's team aims to uncover new phenomena in the quantum states of matter.

Single atoms trapped in a tweezer

In a recent breakthrough, the Léonard group managed to trap single atoms in an optical tweezer array. Optical tweezers are focused beams that hold and move individual atoms, so scientists can view them under the microscope using fluorescence. The atoms can be arranged in a regularly spaced manner or arbitrarily, so they can interact in programmed ways. This work will ultimately help the Léonard group advance quantum computing devices and simulation.

An illustrious career path

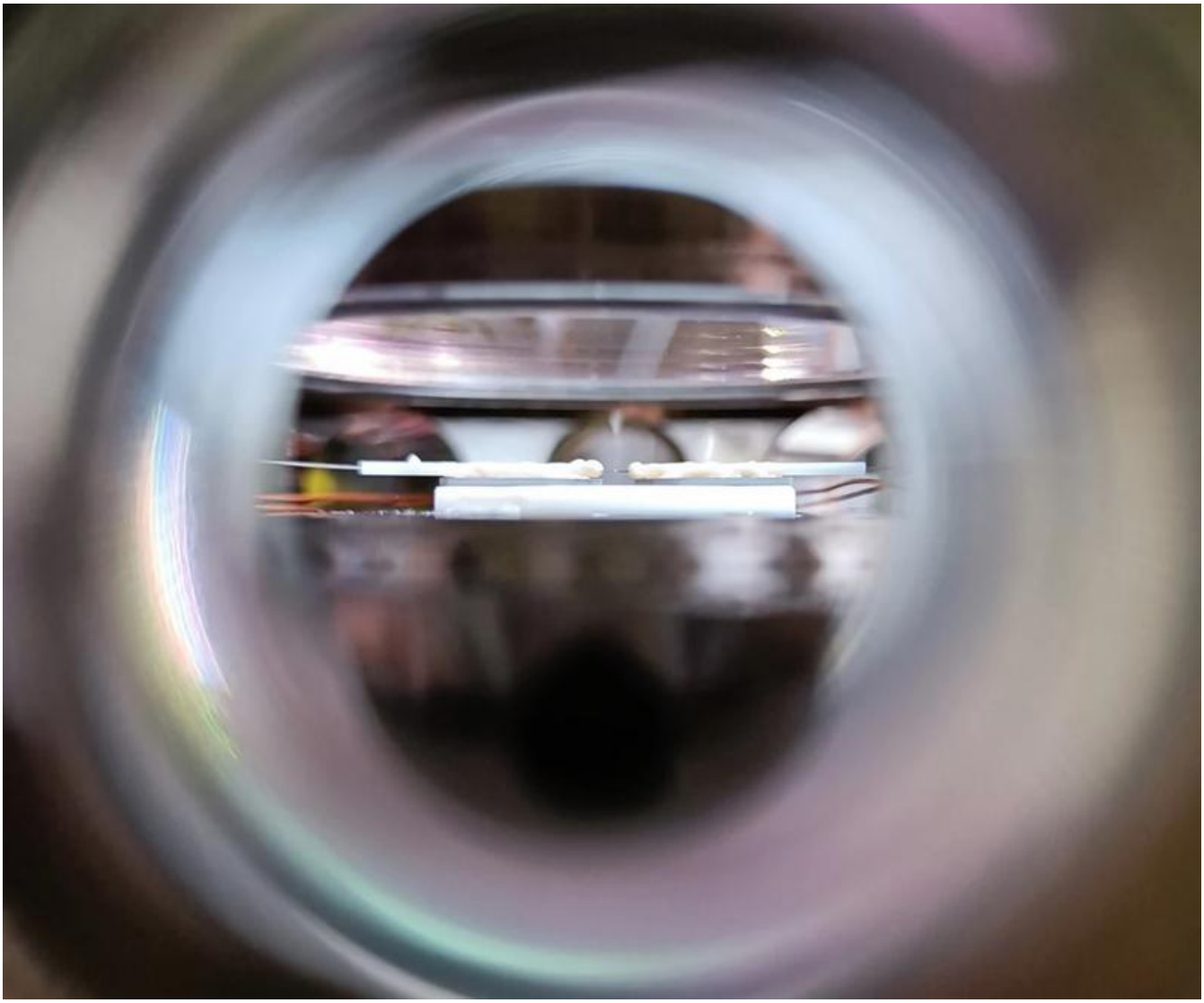
After obtaining his PhD at ETH Zurich, Léonard's path led him to Harvard for a postdoc before starting his research group at the Vienna University of Technology. Now, Léonard is excited about a new start at ISTA. "ISTA has an exceptionally inspiring research environment, and I greatly value the interactions with scientists in diverse fields. I'm excited to build my own state-of-the-art lab and feel well-supported here." Léonard's existing group at TU Wien will move to ISTA over the next year, a new environment in which they will explore new research avenues.

URL zur Pressemitteilung: https://ista.ac.at/en/news/bringing-quantum-mechanics-to-life/ Interview with Julian Léonard

URL zur Pressemitteilung: https://ista.ac.at/en/research/leonard-group/ Léonard Research Group at ISTA

Anhang Single atoms under the microscope. Image of single atoms trapped in the Léonard group's tweezer array http://idw-online.de/de/attachment104063

Assistant Professor Julian Léonard tells how his group can view the quantum interactions between individual atoms under an optical microscope.



Creating new states of matter. A peek into the fiber cavity setup, an instrument used to create new states of matter by sending photons between atoms trapped in an array of optical tweezers.
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