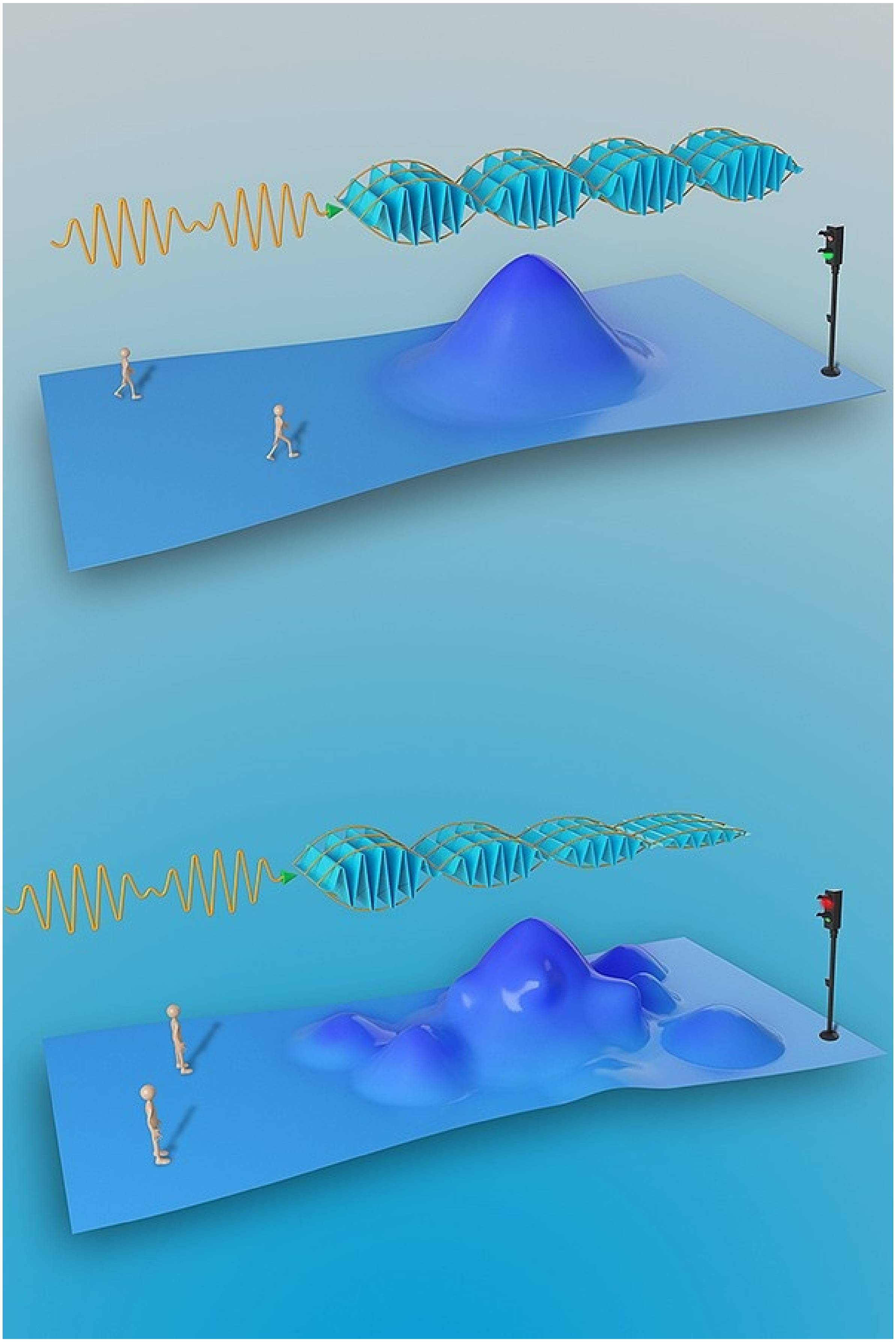
# The quantum technology advancement could help lead to improvements in computing, data processing

September 17 2019, by Cory Nealon



The schematic images show electrons (yellow wavy lines on the left) as quantum waves. In the top image, the wave keeps its form as is passes through the “traffic light.” In the below image, the wave is brought to a halt by the light. The mound-like deformations below the waves represent the shaking of atoms. Credit: University at Buffalo

Stop! In the name of quantum science and engineering.

The familiar refrain relates to a new achievement in quantum technology , an emerging field of research that seeks to harness the unique properties of atoms and subatomic particles.

A University at Buffalo-led research team has developed a "traffic light" that can bring quantum waves to a halt. The advancement could be key to harnessing the potential of the atomic world, eventually leading to breakthroughs in computing, medicine, cryptography, materials science and other applications.

"It's an area of research of immense importance," says UB electrical engineer Jon Bird, Ph.D., co-lead author of a study published recently in the journal *Physical Review Letters* that describes the aforementioned work.

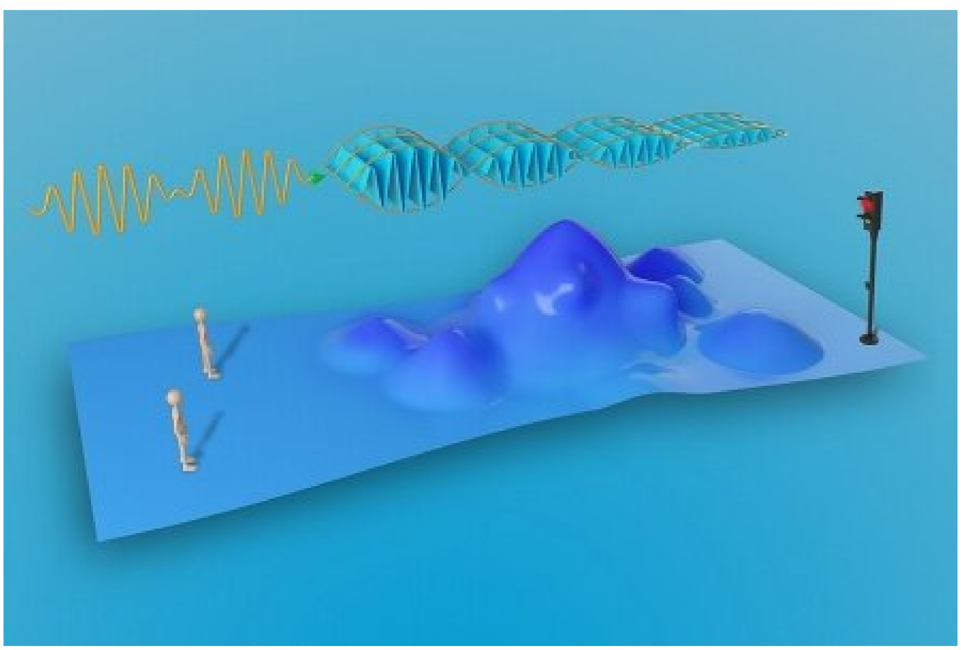
Bird is professor and chair of the Department of Electrical Engineering in the UB School of Engineering and Applied Sciences. Jong Han, Ph.D., professor of physics in the College of Arts and Sciences, is the paper's co-lead author.

Additional authors come from the laboratories of Bird and Han, as well as the Center for Integrated Nanotechnologies at Sandia National Laboratories, and the Korea Institute for Advanced Study.

## The mystery of electrons

While electrons are well-known to schoolchildren, researchers are still trying to understand why these subatomic particles behave the way they do, as well as find new ways to manipulate them.

In the study, the team "used the very atoms that make up the crystal structure of the semiconductor materials that we study to either impede the passage of electrons, or to allow them to pass freely, essentially making a 'traffic light' for these quantum particles. We do this by 'shaking' these atoms controllably, through the application of small electrical signals to our devices," says Bird.



The schematic image show electrons (yellow wavy lines on the left) as quantum waves brought to a halt by the “traffic light.” The mound-like deformations below the waves represent the shaking of atoms. Credit: University at Buffalo

The researchers isolated a specially built nanoconductor at an extremely cold temperature—minus 273 degrees Celsius. Under such conditions, in this ultrasmall device, electrons exhibit a wavelike nature.

In other words, they behave more like ripples on the surface of a pond as opposed to point-like particles, which are often described as billiard-ball like objects that bound around in straight lines.

"Much like light, or waves in the ocean, these quantum waves can behave in ways that we would not expect for particles. They can bend around corners, for example, and the challenge is to develop techniques to control, or steer, them," says Han.

In the study, the UB researchers achieved this by applying a small amount of voltage to the conductor, thereby allowing them to shake its atoms in a controllable fashion. As the atoms were made to shake more strongly, they provided a greater source of resistance to the quantum waves, which blocked the waves from passing through the conductor.

"This is what we call a quantum point contact. You can think of it as a traffic light. Only instead of stopping automobiles at an intersection, we've demonstrated the ability to control the transmission of electron waves in a confined system by externally shaking the atoms in that system," says Han.

## Much more powerful computers

The ability to control subatomic particles such as electrons and photons is key to the development of quantum technologies, especially quantum computers.

Traditional computers process information, or bits, in binary code, meaning they store data and perform calculations by assigning values of "one" or "zero." Quantum computers, which are being developed by IBM, Google and other firms, work with "qubits" that can represent ones and zeros at the same time.

In theory, this approach could lead to much more powerful computers than what exist today. In turn, that would create large economic and national security advantages.

The UB-led research provides a foundational-level implementation of the techniques that are needed to control quantum waves at the microscopic scale, making these technological advancements a possibility, Bird says.

**More information:** Y.-H. Lee et al. Giant Zero Bias Anomaly due to Coherent Scattering from Frozen Phonon Disorder in Quantum Point Contacts, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.123.056802

Provided by University at Buffalo