Helium atoms sent by nozzle may light way for new imaging approach

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A newly devised nozzle fitted with a pinhole-sized capillary has allowed researchers to distribute helium atoms with X-ray-like waves on randomly shaped surfaces. The technique could power the development of a new microscope for nanotechnology, allowing for a non-invasive, high-resolution approach to studying both organic and inorganic materials.

All that is needed is a camera-like detector, which is now being pursued, to quickly capture images that offer nanometer resolution, said principal investigator Stephen Kevan, a physics professor at the University of Oregon. If successful, he said, the approach would build on advances already achieved with emerging X-ray-diffraction techniques.

Reporting in the July 7 issue of *Physical Review Letters*, Kevan's four-member team described how they sent continuous beams of helium atoms and hydrogen molecules precisely onto material with irregular surfaces and measured the speckle diffraction pattern as the wave-like atoms scattered from the surface.

The research, funded by the National Science Foundation and U.S. Department of Education, was the first to capture speckle diffraction patterns using atomic de Broglie waves. The Nobel Prize in physics went to France's Louis de Broglie in 1929 for his work on the properties of matter waves.

"The approach of using the wave nature of atoms goes back 100 years to the founding of quantum mechanics," Kevan said. "Our goal is to make atomic de Broglie waves that have very smooth wave fronts, as in the case in laser light. Usually atom sources do not provide wave fronts that are aligned coherently, or nice and orderly."

The nozzle used in the experiments is similar to one on a garden hose. However, it utilizes a micron-sized glass capillary, borrowed from patch-clamp technology used in neuroscience. The capillary, smaller than a human hair, provides very small but bright-source atoms that can then be scattered from a surface. This distribution of scattered atoms is measured with high resolution using a field ionization detector.

The helium atoms advance with de Broglie wavelengths similar to X-rays, but are neutral and non-damaging to the surface involved. Kevan's team was able to measure single-slit diffraction patterns as well as speckle patterns made on an irregularly shaped object.

Getting a timely image remains the big obstacle, Kevan said. Images of diffraction patterns produced pixel-by-pixel in the study required hours to accumulate and suffer from thermal stability limitations of the equipment. "We'd like to measure the speckle diffraction patterns in seconds, not a day," he said.

"Given its simplicity, relative low cost, continuous availability, and the unit probability for helium scattering from surfaces, our source will be very competitive in some applications," Kevan and colleagues wrote.

"This atom optical experiment would benefit from developing an 'atom camera,' that would measure the entire speckle pattern in one exposure," they wrote.

Source: University of Oregon