Interference of light scattered by two ions

English physicist Thomas Young was the first to demonstrate convincingly that light behaves like a wave. In his famous 1801 experiment, he allowed light to pass through a pair of closely spaced pinholes onto a screen. Each pinhole caused the light to fan out into a wide beam. Where the two beams overlapped on the screen, Young saw bands of bright light alternating with bands of darkness.

Now, a team of physicists has observed for the first time a similar interference pattern created by laser light deflected from two atomic ions held nearly stationary in a special trap. Measurements of the scattered light intensity reveal a pattern of bright and dark bands, or fringes, corresponding to where light waves have either reinforced or canceled each other.

However, when the researchers used detectors that are sensitive to the direction of polarization of the scattered light, they saw an interference pattern for one type of polarized light but no pattern of intensity variations for the other type. The absence of an interference pattern in the latter case can be interpreted as evidence that light also behaves like a particle (or photon).

Thus, in a curious twist on the quantum-physics notion of wave-particle duality, the researchers can demonstrate either the particle or the wave nature of light in the same experiment simply by picking a detector sensitive to the appropriate kind of polarized light.

"We can now have a 'switch' to decide whether we are going to extract the particle-like or wave-like character [of the scattered light]," says Ulli Eichmann of the National Institute of Standards and Technology in Boulder, Colo.

Eichmann and his co-workers describe their experiment in the April 19 PHYSICAL REVIEW LETTERS.

The researchers performed their experiment using two singly charged mercury ions held in place by radio waves. A laser beam tuned to a wavelength of 194 nanometers cooled the ions, keeping them from jiggling excessively. The same beam also served as the light source for the interference experiment.

When Eichmann and his colleagues observed the laser light scattered by the trapped ions, they saw variations in light intensity characteristic of an interference pattern. Moreover, nudging the ions closer together increased the spacing of the pattern's fringes. In other words, the two ions acted just like the pinholes of Young's experiment.

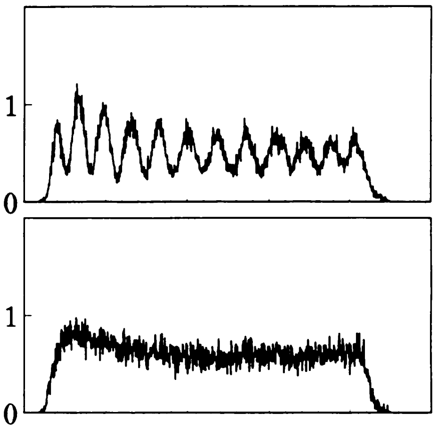
However, the incoming laser light — which is initially polarized so that its electric field points in a particular direction — can interact with the ions in two different ways. In one case, the laser light causes no change in an ion's state and the scattered light remains linearly polarized. Which ion scattered a particular photon can't be determined.

"Quantum mechanics therefore predicts that interference must be present in the light scattered from the two ions," the researchers note.

In the other case, the light excites an ion from its ground state to a slightly higher energy level and the scattered light no longer has a preferred polarization direction. By looking for the excited ion, researchers can, in principle, identify which ion interacted with a particular incoming photon.

"This allows us . . . to distinguish the scattering [ion] from the 'spectator' [ion] and hence to determine which path the photon traveled," Eichmann and his colleagues say. "Consequently, there is no interference in the light scattered from the ions."

Having demonstrated that two ions can produce a scattered-light interference pattern, the researchers suggest that interference measurements themselves may provide a useful alternative method of determining the temperatures and separations of ions held in traps. They are now studying the pattern created by three trapped ions. *— I. Peterson*



When detecting linearly polarized light, the researchers see intensity fluctuations characteristic of an interference pattern (top). No interference pattern appears when they observe circularly polarized scattered light (bottom).

Eichmann *et al.*/NIST

Unusual tubes emerge from boron nitride

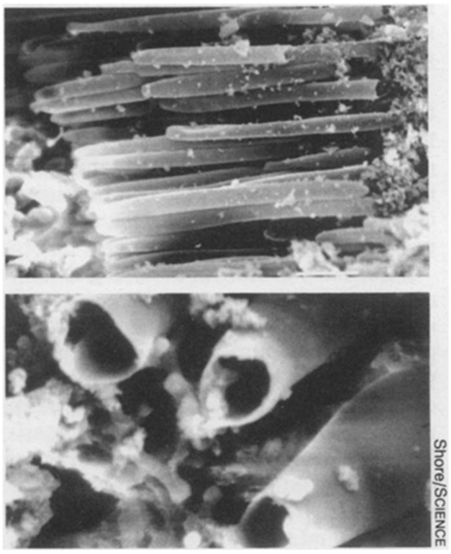
Chemists seeking an alternative method for making boron nitride — a substance used to create hard, diamond-like materials, face powders, and fibers for composite materials — have discovered a new form of the material: microscopic tubes.

"At this point, I think the tubular form is a curiosity," says Sheldon G. Shore, one of the group of chemists at Ohio State University in Columbus who found the tubules. "But it does suggest the possibility that carbon is not the only element that can be made into tubes."

Scientists aiming ultimately to make microscopically thin wires succeeded recently in making superstrong nanometer-size tubes from carbon (SN: 4/3/93, p.214). Boron compounds often resemble those made of carbon (SN: 6/20/92, p.406).

Shore and his co-workers were surprised to see these boron nitride tubes, for two reasons. First, the tubes emerged out of boron nitride's amorphous phase in an ordered, parallel alignment. Second, the boron nitride tubes were about 100 times larger than their carbon counterparts and, unlike them, apparently formed without the aid of a catalyst. The formation mechanism of these unusual tubes, which lack the layered crystalline structure of graphite carbon, continues to puzzle the researchers, Shore says.

In the April 30 SCIENCE, Shore and his colleagues describe how they synthesized amorphous boron nitride with a new procedure involving an explosive reaction between B-trichloroborazine and cesium metal at 125°C. They then heated this material to 1,100°C for 24 hours. The tubes were revealed by scanning electron microscopy (SEM).



SEM images show (top) typical boron nitride tubes 50 to 100 microns long and (bottom) the tube openings, some as much as 3 microns wide.

Shore/SCIENCE

Robert T. Paine of the University of New Mexico in Albuquerque says the team made a "fundamentally interesting observation." But, he adds, "This is an unusual form of the material, and its utility remains to be seen."

Indeed, Shore's group now intends to study the tubes' physical properties. They also plan to try heating the amorphous boron nitride further — to 1,400°C — to see if they can create highly ordered, graphite-like tubes. *— K.F. Schmidt*