Physicists Modify Double-Slit Experiment to Confirm Einstein's Belief

March 12 2007

Work completed by physics professors at Rowan University shows that light is made of particles and waves, a finding that refutes a common belief held for about 80 years.

Shahriar S. Afshar, the visiting professor who is currently at Boston's Institute for Radiation-Induced Mass Studies (IRIMS), led a team, including Rowan physics professors Drs. Eduardo Flores and Ernst Knoesel and student Keith McDonald, that proved Afshar's original claims, which were based on a series of experiments he had conducted several years ago.

An article on the work titled "Paradox in Wave-Particle Duality" recently published in *Foundations of Physics*, a prestigious, refereed academic journal, supports Albert Einstein's long-debated belief that quantum physics is incomplete. For eight decades the scientific community generally had supported Niels Bohr's ideas commonly known as the Copenhagen Interpretation of Quantum Mechanics. In 1927, in his "Principle of Complementarity," he asserted that in any experiment light shows only one aspect at a time, either it behaves as a wave or as a particle. Einstein was deeply troubled by that principle, since he could not accept that any external measurement would prevent light to reveal its full dual nature, according to Afshar. The fundamental problem, however, seemed to be that one has to destroy the photon in order to measure either aspects of it. Then, once destroyed, there is no light left to measure the other aspect.

“About 150 years ago, light was thought to behave solely as a wave similar to sound and water waves. In 1905, Einstein observed that light might also act as being made out of small particles. Since then physicists found it difficult understanding the full nature of light since in some situations it acts like a particle and in others like a wave,” Flores said. “This dual nature of light led to the insight that all fundamental physical objects include a wave and a particle aspect, even electrons, protons and students.”

Afshar conducted his initial theoretical and experimental work at IRIMS, where he served the privately funded organization as a principal investigator. He later continued his work at the Harvard University Physics Department as a research scholar, where he was able to verify his initial findings before going to Rowan.

In 2004, Afshar claimed that he had devised an experiment that challenged Bohr’s principle of complementarity. The Rowan team was formed to verify Afshar’s claim at extremely low light intensity levels. Afshar, Flores and Knoesel conducted experiments at Rowan that validated Afshar’s initial findings for single photons.

In this modified double-slit experiment, a laser beam hits a screen with two small pinholes. As a particle, light goes through one of the pinholes. Through a lens system, the light is then imaged onto two detectors, where a certain detector measures only the photons, which went through a particular pinhole. In this way, Afshar verified the particle nature of light. As a wave, light goes through both pinholes and forms a so-called interference pattern of bright and dark fringes.

“Afshar’s experiment consists of the clever idea of putting small absorbing wires at the exact position of the dark interference fringes, where you expect no light,” Knoesel said. “He then observed that the wires do not change the total light intensity, so there are really dark

fringes at the position of the wires. That proves that light also behaves as a wave in the same experiment in which it behaves as a particle."

The findings of the Afshar experiment were published online on January 23 in the *Foundations of Physics*, an international journal devoted to the conceptual bases and fundamental theories of modern physics, biophysics and cosmology, with several distinguished Nobel laureates on its editorial board. The print version was published in the February 2007 edition and is now available in libraries throughout the world.

"The important new contribution is that light carries both wave and particle aspects at all times, and future experiments will further clarify the nature of each component." Afshar said.

Flores continued, "It is interesting to note that even after 80 years we can still gain a better understanding about the nature of light using refined measurement techniques and creative ideas and therefore are able add to the vast insights of former scientists."

Citation: Paradox in Wave-Particle Duality, Shahriar S. Afshar, Eduardo Flores, Keith F. McDonald and Ernst Knoesel, *Foundations of Physics*, 23 January 2007, DOI 10.1007/s10701-006-9102-8

Source: Rowan University