Photoemission 100 years after Einstein

April 28 2005

In 1921 Einstein won the Nobel Prize not for his work on relativity, but for solving a puzzle that had baffled scientists since 1887 – the photoelectric effect. In one of the three ground-breaking papers he published in 1905 he explained it in one astonishing blow: the light is quantized. His work was the first step in launching quantum theory. Tomorrow New Journal of Physics (NJP) publishes a special celebratory focus issue containing a series of new papers looking at the latest applications of the phenomenon first explained by Einstein one hundred years ago. NJP is co-owned by the Institute of Physics and Deutsche Physikalische Gesellschaft (the German Physical Society).

First noticed by Hertz in 1887, the photoelectric effect is the emission of electrons from a surface (usually metallic) on exposure to electromagnetic radiation (such as visible light and ultraviolet radiation).

On 17 March 1905 - three days after his 26th birthday - Einstein submitted a paper titled "A heuristic point of view concerning the production and transformation of light" to Annalen der Physik. In it he suggested that light can be thought of as individual packets or “quanta” of energy. This hypothesis, which had been tentatively proposed by Max Planck a few years earlier, directly challenged the wave theory of light. However, Einstein was able to use the idea to explain certain puzzles about the way that light, or other electromagnetic radiation, ejected electrons from a metal via the photoelectric effect.

"The arguments Einstein used in the photoelectric and subsequent radiation theory are staggering in their boldness and beauty," says Frank

Wilczek, a theorist at the Massachusetts Institute of Technology who shared the 2004 Nobel Prize for Physics. "He put forward revolutionary ideas that both inspired decisive experimental work and helped launch quantum theory." Although not fully appreciated at the time, Einstein's work on the quantum nature of light was the first step towards establishing the wave-particle duality of quantum particles.

Photoemission is now one of the major tools for detailed investigations of the electronic structure of matter and contributes heavily to our understanding of the properties of matter. It provides the complete set of quantum numbers for electrons in a solid and has been called the “smoking gun” for solving difficult puzzles in condensed matter physics.

This celebratory focus issue of NJP shows examples of the rich variety of applications of the phenomenon first explained by Einstein one hundred years ago.

Franz Himpsel, guest editor of the issue, said: “The papers in this special issue demonstrate some of the new directions in photoemission. For example, how scientists are now designing fast electronic devices using “hot electrons”, and complex materials such as high-temperature superconductors which has opened a new field of tailored electronic materials where the electrons are highly correlated”.

Source: Institute of Physics