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Quantum Tunneling Observed in Real-Time

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20 April 2007 - In classical physics, an object would travel over a mountain to get to the other side, while in quantum physics, an object is able to pass through the mountain by quantum tunnelling. Researchers at the Max Plank Institute for Quantum Optics have observed the quantum tunnelling of electrons in real-time. The team of researchers used extremely short laser pulses to ionize gas molecules and observe quantum tunnelling by electrons. Their results are published in the April 5, 2007 issue of *Nature*.

"For the first time, our findings confirmed in real time observation the theoretical predictions of quantum mechanics," says Ferenc Krausz, Director at the Max Planck Institute for Quantum Optics and senior author of the paper.

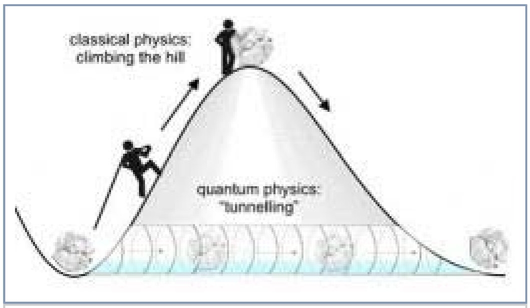
In an atom, electrons, protons, and neutrons are arranged to give the most stable and lowest binding energy, or potential. This lowest binding energy arrangement can be visualized as valley with the atom in the bottom of the valley. In quantum physics, electrons are capable of tunnelling through the walls of the valley. This is possible because quantum mechanics states every particle and object in the universe has both a wave nature in addition to its particle nature under classical physics. However, this wave-particle duality has only been observed at the atomic level. It is the wave-like nature of the electrons that allows them to undergo quantum tunnelling.

In the study, Krausz and his team used two light pulses to ionize neon atoms. The first pulse consisted of intense red laser light and the second pulse was an attosecond (a fraction of a trillionth of a second) pulse of extreme ultraviolet (XUV) light. The pulse of XUV light was synchronized with the red laser light pulse. Electrons hit by an attosecond pulse of XUV were pushed to the periphery of the atom, and able to quantum tunnel from the atom. This eventually resulted in the formation of charged ions that were detected by mass spectrometry.

"The experiments not only provide us with insight into the dynamics of electron tunnelling for the first time," says Krausz, "…[but] also [show] that the movement of electrons in atoms or molecules can be observed in real time with the aid of laser field-induced tunnelling."

The findings by Krausz and his team will facilitate further insights into the quantum properties of matter. Krausz's attosecond techniques may also help to improve our understanding of quantum tunnelling, which has important applications in semiconductor physics and products such as flash memory.

Written by Charles Tran



There are two paths of getting to the other side of a mountain. In classical physics, one must climb the mountain to get to the other side. In quantum physics, objects can cross the mountain by tunnelling horizontally through it. Image courtesy of the Max Planck Institute for Quantum Optics. (Click image for larger version)