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Bloch Oscillations Observed in Quantum Gas

A group in the team of START prize winner Hanns-Christoph Nägerl at the University of Innsbruck succeeded in suppressing the interaction between atoms in an ultracold quantum gas, which enabled them for the first time to observe a quantum-mechanical phenomenon, the so-called Bloch oscillations, over a longer period and with great accuracy. The researchers report their findings in the current issue of the scientce journal *Physical Review Letters*.

In the early years of quantum mechanics theoreticians already predicted a puzzling phenomenon: if a voltage is put to an ideal, noise-free wire, there is no current – the electrons in the crystal lattice of a perfect solid state oscillate under the influence of a constant force around an inert state without moving on. This oscillation was named after one of the founders of solid state physics, Swiss scientist Felix Bloch. It took until the 1990s for Bloch oscillations to be observed in an experiment for the first time within special semi-conductor structures.

Observation lasting 10 seconds

The researcher group of professor Hanns-Christoph Nägerl have now used an ultracold quantum gas of caesium atoms as their model system for studying Bloch oscillations. “We had to suspend the interaction between the particles for our experiment,” Nägerl explains, “otherwise they would bang into each other and disrupt the oscillation.” The researchers laid an optical lattice over the ultracold atoms and used a so-called Feshbach resonance to suppress the interfering interaction between the particles. “So far we are the only ones worldwide who can do that to perfection,” a delighted Nägerl explains. The atoms are speeded up by gravity and receive a pulse. At a particular point in the experiment they are abruptly slowed down and thrown back. The researchers measure the speed with which the particles move. “From the pulse distribution we can read off the Bloch oscillations with great accuracy,” the experimental physicist proudly comments. “What is special about our experiment is the long observation period of more than ten seconds. In the world of elementary particles this is ages.”

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START prize shows results

Such an experiment could find an application in determining natural constants ever more precisely or exploring fundamental physical phenomena such as gravitation. “We hope that with our experiment phenomena such as the fine-structure constant α can be measured to a level of accuracy so far unknown,” says professor Hanns-Christoph Nägerl, 2003 winner of the START prize, the highest Austrian award for young scientists. The current research came out of an experiment which has been built up over the last four years and funded by the START prize money provided by the Federal Ministry for Science and Research (bm:wf) and the Science Fund (FWF). The research project is based at the Institute of Experimental Physics at the University of Innsbruck. Physicists at the European Laboratory for Non-Linear Spectroscopy (LENS) in Florence have carried out a similar experiment and published their findings jointly with the Innsbruck research in the current issue of Physical Review Letters.

Publication: Control of Interaction-Induced Dephasing of Bloch Oscillations. M. Gustavsson, E. Haller, M. J. Mark, J.G. Danzl, G. Rojas-Kopeinig, H.-C. Nägerl. Phys. Rev. Lett. 100, 080404 (2008) [http://link.aps.org/abstract/PRL/v100/e080404]

You can find pictures on: http://www.iqoqi.at/media/download/

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