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A mysterious change in the wave properties of electrons

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The electrons of a perfect metallic surface move like free waves in a plane. Nevertheless, if atomic barriers are inserted, this may restrict their movement in one dimension, forming stationary waves such as those on the water surface in a bucket.
The stationary or free behaviour of electron waves is, nevertheless, still something very intriguing, given that the barriers of atoms are very close to each other, there is no confinement, and that the electron recovers its free movement, exactly as was discovered some years ago by the Nanophysics Laboratory research team led by Enrique Ortega at the Donostia-San Sebastian campus of the University of the Basque Country.

The Physical Review Letters has just published the results of new research this team has been undertaking since 1999 on the wave properties of electrons: the critical size of the step is 2 nanometres, i.e., if the distance of the barriers is superior to 2 nanometres, the electrons form stationary waves; if it is inferior, the waves are free.

More specifically, Enrique Ortega has formed a new nanostructure, i.e. a typical nanometre-sized structure (a nanometre being a thousand millionth or a billionth of a metre) by depositing small quantities of silver on a copper surface. The system arranges itself by forming a network of nanostrips of silver and copper. The copper strips show atomic steps with a step width that depends on the amount of silver deposited. On varying the width, one can observe in detail the transformation of the stationary waves confined between the steps of atomic height in waves of electrons that move freely.

In this way the critical size of the step of 2 nanometres has been discovered: less than this width free waves exist and widths greater than this critical figure are confined. “The detailed study of this transition will be fundamental in the future when establishing the wave properties of electrons in metallic nanostructures", stated Enrique Ortega.

According to Doctor Ortega, the most difficult part of the investigation was constructing the system by which the measurement was to be carried out. These kinds of trials have to be undertaken in ultra high vacuum systems, where not even the smallest particle can be present, as the least amount of contamination will destroy the system. They are also systems difficult to extract information from. Moreover, it is necessary to create a structure limited to a width of 4 or 5 atoms, controlling all the parameters at the same time, demanding a complex prior process.

This is the sixth time that Dr Ortega, leader of the only experimental physics group working on nanostructures in Euskadi, has published an article in Physical Review Lettersz. Regarding the applications for the discovery, the researcher points out that “although, in the field of nanoscience, one always has to go through a number of phases, we cannot discard its utility, certainly in the field of what will be the electronics of the future - nanoelectronics”.

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