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Putting the right spin on nano-electronics

Thanks to a quantum physics breakthrough, European and American physicists are, electron-by-electron, pushing back the resistance barriers stifling current generation computers and high-speed, high-powered electronics. But as fundamental researchers, they say their work is not about end products, but the thrill of discovery.Today, all electronics are based on transistors, and they are getting smaller, faster and more powerful – a trend likely to continue in light of recent news reported in a July issue of Nature Physics. Two Danish physicists at the Copenhagen University (CU) have mastered a technique for migrating electrons in a nano-transistor. Using quantum physics, the scientists have got the electrons at either end of a carbon nano-tube 'talking' to each other in perfect pitch.Jens Paaske of the Nano-Science Centre and Niels Bohr Institute at CU, who was responsible for the theoretical part of the experiment, said the breakthrough was made possible thanks to excellent collaboration with his experimental colleague Jesper Nygård of the Niels Bohr Institute and colleagues at Universität Karslruhe, Germany, and Harvard University, USA. A relationship borne out of friendship and international training.“I first started working with tiny molecular transistors and theories for how to push electrons through single-walled carbon nanotubes about four years ago in Germany where I was doing postdoc work,” Paaske told Headlines. But there was only so far he could go with his ideas without input from experimental physicists who could help with the cooling of the electrons – entering the quantum realm.Basically, he explains, at temperatures near absolute zero (–270°C), the so-called ‘spin’ of the electrons gets each one acting like a little magnet, jumping one-by-one from one end of the nanotube to the other and building up momentum until they reach ‘quantum mechanic cohesion’ – technically known as a Kondo resonance. “By this stage, we’re getting clean communication between the two poles with perfect flow of electrons, lowering resistance and heat build up,” he notes. “The electrons are actually helping each other through the molecule in the nano-transistor.”It’s still fundamental, thoughThis achievement is not only a breakthrough in the fundamental research of nanotechnology, the Niels Bohr Institute notes in a statement, “it also influences the development of tomorrow's electronics, such as future super-fast quantum computers”.But Paaske still stresses the fundamental nature of the demonstration. “We’re looking at the result in two ways,” he says. First, it is a fundamental building block in molecular electronics, with the idea of one day mixing transistors in a test tube, pouring them out and letting them organise, or ‘talk’, amongst themselves. “This would make them not only cheaper but also faster, as they self-organise,” he adds.The second factor is that, by controlling the spin over the electrons – pure quantum electronics – you are then controlling it well enough to manipulate a “quantum bit”, which is the basic building block in a ‘quantum computer’. Significant research efforts worldwide are being put into the quest to develop this quantum computer. While it is still at the vision stage, the result from Copenhagen shows that the necessary quantum properties can be realised in a nanotube transistor at low temperatures.Nygård says discovering how to control the way electrons move through nano-transistors is all the more satisfying as it is a shared experience built on years of work spanning two continents. Guided by the work of Harvard professor Charlie Marcus in the field of quantum electronics, Nygård returned to Denmark and began what turned out to be a very successful partnership with Paaske, resulting in a worldwide breakthrough in quantum nano-electronics.In another example of international collaboration, Paaske has also been taking part in the EU-funded CANEL project, which is a three-country – Sweden, Denmark, the Netherlands – tie up to integrate carbon-based nano-electromechanical devices into silicon technology. The 36-month project, funded to the tune of €1.8 million by the EU’s Information Society Technologies programme, kicked off in 2004 and is focusing on applications in information technology, such as switches and memory elements.Source: European Commission

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