fields between finger-electrodes induce a sound wave to propagate along the surface of the material.

These acoustic waves have the ability to scoop electrons and chauffeur them along the surface.

The tiny region confining the electron even as it moves is in effect a quantum dot. Such acoustic-based dynamic quantum dots have made before, but according to Cambridge researcher Michael Astley, this is the first time the tunneling of the electrons (even single electrons) into and out of the quantum dots has been observed. This is an important part of the whole electron-shuttling process since one wants control over the electron motions and spins. If, moreover, electrons in two very close acoustic wave channels could be entangled, then this would present the chance to make a sort of flying qubit, which could be at the heart of a quantum computer. (Astley et al., *Phys. Rev. Lett*. **99**, 156802 (2007))

Thermal Logic Gates

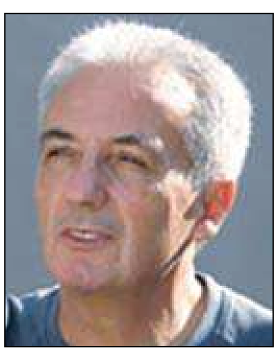
Information processing in the world's computers is mostly carried out in compact electronic devices, which use the flow of electrons both to carry and control information. There are, however, other potential information carriers, such as photons. Indeed a major industry, photonics, has developed around the sending of messages encoded in pulsed light.

Heat pulses, or phonons, rippling through a crystal might also become a major carrier, says Baowen Li of the National University of Singapore. Li, with his colleague Lei Wang, have now shown how circuitry could use heat–energy already present in abundance in electronic devices–to carry and process information.

They suggest that thermal transistors (also proposed by Li's group in Applied Physics Letters, 3 April 2006) could be combined into all the types of logic gates–such as OR, AND, NOT, etc.–used in conventional processors and that therefore a thermal computer, one that manipulates heat on the microscopic level, should be possible.

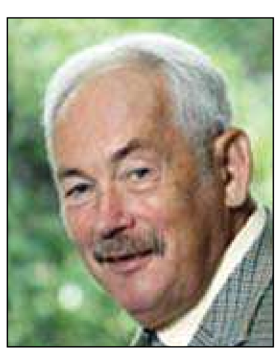
Given the fact that a solid state thermal rectifier has been demonstrated experimentally in nanotubes by a group at UC Berkeley (Chang et al., *Science*, 17 November 2006) only a few years after the theoretical proposal of "thermal diode," the heat analog of an electrical diode which would oblige heat to flow preferentially in one direction (Li et al, *Phys. Rev. Lett*. **93**, 184301 (2004)). Li is confident that thermal devices can be successfully realized in the foreseeable future. (Wang and Li, *Phys. Rev. Lett*. **99**, 177208 (2007))

2007 Nobel Prize in Physics


Albert Fert

The 2007 Nobel Prize in Physics was awarded to Albert Fert (Université Paris-Sud, Orsay, France) and Peter Grünberg (Forschungszentrum Jülich, Germany) for the discovery of giant magnetoresistance, or GMR for short. GMR is the process whereby a magnetic field, such as that of an oriented domain on the surface of a computer hard drive can trigger a large change in electrical resistance, thus "reading" the data vested in the magnetic orientation.

This is the heart of modern hard drive technology and makes possible the immense hard-drive data storage industry. Fert and Grünberg pioneered the making of stacks consisting of alternating thin layers of magnetic and nonmagnetic atoms needed to produce the GMR effect. GMR is a prominent example of how quantum effects (a large electrical response to a magnetic input) come about through confinement (the atomic layers being so thin); that is, atoms interact differently with each other when they are confined to a tiny volume or a thin plane.


Peter Grünberg

All these magnetic interactions involve the spin of an electron. Still more innovative technology can be expected through quantum effects depending on electrons' spin. Most of the electronics industry is based on manipulating the charges of electrons moving through circuits. But the electrons' spins might also be exploited to gain new control over data storage and processing. Spintronics is the general name for this budding branch of electronics. (Nobel Prize website: http://nobelprize.org/nobel_prizes/physics/laureates/2007/info.html)

Relativistic Thermodynamics

Einstein's special theory of relativity has formulas, called Lorentz transformations, that convert time or distance intervals from a resting frame of reference to a frame zooming by at nearly the speed of light. But how about temperature? That is, if a speeding observer, carrying her thermometer with her, tries to measure the temperature of a gas in a stationary bottle, what temperature will she measure? A new look at this contentious subject suggests that the temperature will be the same as that measured in the rest frame. In other words, moving bodies will not appear hotter or colder.

You'd think that such an issue would have been settled decades ago, but this is not the case. One problem is how to define or measure a gas temperature in the first place. James Clerk Maxwell in 1866 enunciated his famous formula predicting that the distribution of gas particle velocities would look like a Gaussian-shaped curve. But how would this curve appear to be for someone flying past? What would the equivalent average gas temperature be to this other observer? Jorn Dunkel and his colleagues at the Universitat Augsburg (Germany) and the Universidad de Sevilla (Spain) could not exactly make direct measurements (no one has figured out how to maintain a contained gas at relativistic speeds in a terrestrial lab), but they performed extensive simulations of the measurement.

Dunkel says that some astrophysical systems might eventually offer a chance to experimentally judge the issue. In general the effort to marry thermodynamics with special relativity is still at an early stage. It is not exactly known how several thermodynamic parameters change at high speeds. Absolute zero, Dunkel says, will always be absolute zero, even for quickly-moving observers. But producing proper Lorentz transformations for other quantities such as entropy will be trickier to do. (Cubero et al., *Phys. Rev. Lett*. **99**, 170601 (2007))

Nuclear Dripline Droops

Several new heavy isotopes have been discovered, at least one of which pushes beyond the neutron dripline. Driplines are the outer edges defining the zone of observed or expected bound nuclei on a map whose horizontal axis is the number of neutrons in a nucleus (denoted by the letter N) and whose vertical axis corresponds to the number of protons (Z). The nuclear force holding neutrons and protons together (even as the like-charged protons repel each other electrostatically) is so strong that no theory (not even the so called nuclear shell model, fashioned in analogy to the atomic model) can confidently predict whether a particular combination of neutrons and protons will form a bound nucleus. Instead experimenters must help theorists by going out and finding or making each nuclide in the lab.

In an experiment conducted recently at the National Superconducting Cyclotron Lab (NSCL) at Michigan State University, a beam of calcium ions was smashed into a tungsten target. A myriad of different nuclides emerged and streamed into a sensitive detector for identification. Two newly found nuclides–Mg-40 and Al-43–came as no surprise. But another, Al-42, was more unusual since it violated the provisional prohibition against nuclei of this size having an odd number of protons and neutrons.

The new nuclides are not stable, since they decay within a few milliseconds. But this is pretty long by nuclear standards. Why study such fleeting nuclei? Even though they might not exist naturally, the new nuclides still might play a role inside stars or novas where heavy elements, including those that make up our planet and our bodies, are created. Thomas Baumann suggests that even heavier aluminum-isotopes might exist, and that it is worth exploring any possible islands of stability, not just those at the very edge of the periodic table. (Baumann et al., *Nature* **449**, 1022-1024 (25 October 2007))

The Highest-Energy Cosmic Rays

The highest-energy cosmic rays probably come from the cores of active galactic nuclei (AGN), where supermassive black holes are thought to supply vast energy for flinging the rays across the cosmos. This is the conclusion reached by scientists who operate the Pierre Auger Observatory in Argentina. This gigantic array of detectors spread across 3000 sq. km of terrain, looks for one thing: cosmic ray showers.

These arise when extremely energetic particles strike our atmosphere, spawning a gush of secondary particles. Many of the rays come from inside our own Milky Way, especially from our sun, but many others come from far away. Of most interest are the highest-energy showers, with energies above 10^{19} electron volts, far higher than any particle energy that can be produced in terrestrial accelerators. The origin of such potent physical artifacts offers physicists a tool for studying the most violent events in the universe.

To arrive at Earth, most cosmic rays will have crossed a great deal of intergalactic space, where magnetic fields can deflect them from their starting trajectories. But for the highest-energy rays, the magnetic fields can't exert as much influence, and consequently the starting point for the cosmic rays can be traced with some confidence.

This allowed the Auger scientists to assert that the highest-energy cosmic rays were not coming uniformly from all directions but rather preferentially from galaxies with active cores, where the engine for particle acceleration was probably black holes of enormous size. The very largest of cosmic ray showers, those with an energy higher than 57 EeV (1EeV equals 10^{18} eV), correlated pretty well with known AGN's. (Auger collaboration, *Science* **9** November 2007: Vol. 318. no. 5852, pp. 938-943)

Cooper Pairs in Insulators

Cooper pairs are the extraordinary link-up of like-charged electrons through the subtle flexings of a crystal. They act as the backbone of the superconducting phenomenon, but have also now been observed in a material that is not only non-superconducting but actually an insulator. An experiment at Brown University measures electrical resistance in a Swiss-cheese-like plank of bismuth atoms made by spritzing a cloud of atoms onto a substrate with 27-nm-wide holes spaced 100 nm apart. Bismuth films made this way are superconducting if the sample is many atom-layers thick but is insulating if the film is only a few atoms thick, owing to subtle effects which arise from the restrictive geometry.

Cooper pairs are certainly present in the superconducting sample; they team up to form a non-resistive supercurrent. But how do the researchers know that pairs are present in the insulator too? By seeing what happens to resistance as an external magnetic field is increased.

The resistance should vary periodically, with a period proportional to the charge of the electrical objects in question. From the periodicity, proportional in this case to two times the charge of the electron, the Brown physicists could deduce that they were seeing doubly-charged objects moving through the sample. In other words, Cooper pairs are present in the insulator. This is true only at the lowest temperatures. One of the researchers, James Valles, says that there have been previous hints of Cooper pairs in some films related to superconductors, but that in those cases the evidence for pairs in the insulating state was ambiguous. He asserts that the realization of a boson insulator (in which the charge carriers are electron pairs) will help to further explore the odd kinship between insulators and superconductors. (Stewart et al., *Science* **23** November 2007: Vol. 318. no. 5854, pp. 1273-1275)

Persistent Flow or Bose-Condensed Atoms in a Toroidal Trap

A persistent flow of Bose-condensed atoms has been achieved for the first time, offering physicists a better chance to study the kinship between Bose-Einstein condensates (BEC) and superfluids. Both involve the establishment of an ensemble in which many atoms join together in a single quantum entity. But they're not quite the same thing. In a bath of liquid helium at low temperatures, for example, nearly 100% of the atoms are in a superfluid state but only about 10% are in a BEC state (in a BEC millions of atoms have become, in a sense, a single atom). But physicists generally believe that most or all of a BEC is superfluid. Scientists have been able to stir up quantized vortices in BEC samples, one indication that BECs are superfluid. But until now researchers had not been able to get BECs to move around a track in a persistent flow, another sign of superfluidity.

The new experiment, performed by Nobel laureate William Phillips and his colleagues at NIST-Gaithersburg, the Joint Quantum Institute of NIST and the University of Maryland, chilled sodium atoms in a toroidal trap, set them into motion with laser light, and observed a flow for as long as 10 seconds.

One of the scientists on the project, Kristian Helmerson, says that neutral atoms flowing in a toroidal vessel could be fashioned into the atom analog of a superconducting quantum interference device (SQUID), which is used as a sensitive detector of magnetism. This BEC device, sensing not magnetism but slight changes in direction, could serve as a sensitive gyroscope, possibly for navigation purposes. (Ryu et al., *Phys. Rev. Lett*. **99**, 260401 (2007))