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results, they hypothesize that black carbon fluxes to deep-sea sediments are linked to wind speed and direction. In this case, soils would be the main intermediate pool for sedimentary black carbon. Certainly, further measurements of black carbon in sediments as well as in river and ocean water are necessary to address the above question. Additionally, the source strength of aged black carbon from soils becoming airborne by wind erosion should be investigated as well.

But, most importantly, we need to develop an experimentally acceptable definition of black carbon and intercalibrate the various analytical techniques if we wish to build a meaningful data set. Certainly, to understand the role of black carbon and thus of any combustion process in the environment, a complete understanding of the life cycle of black carbon is necessary.

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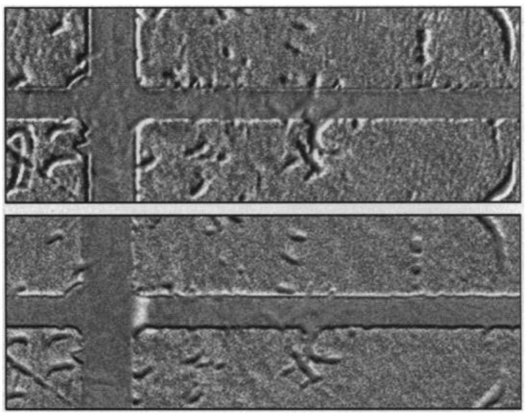
CONDENSED MATTER PHYSICS

Hot Electrons in Magnetic Oxides

B. Keimer

An electron subjected to a high electric field inside a material can become fast or "hot" enough to ionize impurities encountered in its path. The secondary electrons set free in the collision then ionize other impurities and so forth, leading to an avalanche of electrons. The resulting current surge is exploited in common semiconductor devices such as photodiodes, microwave oscillators, and electronic switches (*1*). On page 1925 of this issue, Fiebig *et al.* report the observation of an avalanche instability in an oxide material very different from ordinary semiconductors (*2*). It belongs to a class of magnetic oxide compounds whose resistivity is exceedingly sensitive to modest magnetic fields ("colossal magnetoresistance"). By driving this material far from thermodynamic equilibrium and monitoring its response, Fiebig *et al.* have developed an approach that promises to reveal new physics and, over time, may also lead to novel device applications.

The states near the Fermi level of the compound they investigated, $Pr_{0.7}Ca_{0.3}MnO_3$, derive predominantly from the Mn 3d orbitals, and the average number of electrons per Mn atom is 3.7. The five degenerate atomic d orbitals are split into a triplet and a doublet by interactions with the crystalline environment. The lower-lying triplet on each Mn atom is filled by three electrons that form a local spin-3/2. The remaining 0.7 electrons partially occupying the doublet are forced by intra-atomic Coulomb interactions to align with the local spin. (This is analogous to the familiar Hund's rule of atomic physics.)



Current events. Images of current flow inside a material exhibiting a metal-insulator transition that produces a change in reflectivity. The phase transition is induced by pulses of laser light while voltage is applied; this allows current to flow, maintaining the conducting state. (**Top**) Sample in reflected light showing its normal insulating state. (**Bottom**) After phase transition is initiated, highly reflecting regions show current path.

Two different thermodynamic phases can occur in this and related manganite compounds: an insulating phase in which the electrons in the doublet are also localized and crystallize in a regular pattern with an antiferromagnetic spin alignment, and a metallic phase in which they are delocalized (see figure). The former phase is favored by electrostatic interactions and forms when $Pr_{0.7}Ca_{0.3}MnO_3$ is cooled to low temperatures (≤200 K) in zero magnetic field (*3*). In this insulating phase, the additional static charge localized on the Mn site lifts the degeneracy of the doublet by distorting the surrounding lattice (the so-called Jahn-Teller effect), thus lowering the energy of the occupied state. Furthermore, the electrons spend most of their time far away from each other when they are localized, so that their mutual Coulomb repulsion is also minimized. However, according to the Heisenberg uncertainty principle, the kinetic energy of a quantum particle increases as it is localized. When an external magnetic field aligns the local spins ferromagnetically and facilitates hopping of the conduction electrons from site to site, the energy balance is tipped in favor of this kinetic term, and the material undergoes a first-order transition to the metallic phase. This is the basic mechanism of the colossal magnetoresistance effect.

Contrary to conventional semiconductors, where the conduction electrons are dilute and weakly interacting, this phenomenology indicates that both electron-lattice and electron-electron interactions are strong in these oxides. This has been corroborated by numerous experimental studies under equilibrium and near-equilibrium conditions. What happens when such a strongly interacting quantum system is driven far from equilibrium?

On the face of it, the observations reported by Fiebig *et al.* (*2*) in $Pr_{0.7}Ca_{0.3}MnO_3$ actually bear much resemblance to the behavior of some conventional semiconductors under similar conditions (*4*). In both systems, application of a high electric field, sometimes enhanced by laser irradiation, results in the formation of highly conducting

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current filaments. This happens because the electrical resistivity in the avalanche regime decreases with electric field (a special case of a more general phenomenon called negative differential resistance). If, due to a local inhomogeneity, the electric field is larger than average in some region of the material, its resistivity is thus reduced below average. More current flows into the region, and it elongates until it forms a current filament extending all the way through the material (see figure).

These similarities are deceptive, however, as the physics underlying the negative differential resistance is almost certainly very different in the two classes of materials. In conventional semiconductors, its origin is thought to be essentially a single electron effect: As the electric field is increased, a given electron can acquire more energy before it collides with an impurity, and the likelihood of impact ionization increases. By contrast, more complex many-body effects appear to be at work in $Pr_{0.7}Ca_{0.3}MnO_3$.

Indeed, the experimental evidence suggests that the region inside the current filament is characterized not only by a much higher density of free electrons than the surrounding insulating medium but also by a collective ferromagnetic alignment of the local spins, as in the magnetic field–induced equilibrium metallic phase. Some of the most persuasive evidence comes from a different type of experiment, where $Pr_{0.7}Ca_{0.3}MnO_3$ is irradiated by x-rays and hot electrons are generated by photoionization (5). In this case, the hot electron-induced metallic phase persists even after the x-ray beam is switched off and can thus be directly compared with the magnetic field–induced phase. Why the conducting phase observed in the electric breakdown experiments (2, 6) does not also persist when the electric field is switched off is one of the puzzles we are left with at this stage.

To understand how hot electrons manage to convert an antiferromagnetic insulator to a ferromagnetic metal, the interaction and thermalization of these electrons with a background of correlated spins need to be systematically addressed. The behavior of these and other magnetic oxides far from equilibrium may well help us develop general concepts for electronic transport in the presence of strong interactions among the various electronic and lattice degrees of freedom, an endeavor that is currently at the frontier of solid-state physics. In the long run, it is also conceivable that magnetic effects induced by hot electrons will be put to work in new generations of electronic devices.

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AIDS

Aligning Science with Politics and Policy in HIV Prevention

Karen Hein

"Spread the word—not the virus" has been a mantra among AIDS activists since the beginning of the HIV epidemic. Educating people about the virus and risk of infection, getting people to behave in ways that reduce risk, and increasing understanding and compassion for those infected are widely accepted societal goals. Efforts to prevent HIV infection have undoubtedly saved many lives, just as new combination therapies have delayed death for many infected individuals. However, the incidence of HIV remains steady (see the figure), a fact that reminds us that more effective preventive measures are needed. Recently, deaths from AIDS have decreased, partially as a result of more effective treatments (see the figure), but new infections continue to rise in many segments of the American population (1) and in most segments of developing nations. We can now answer three questions: Does HIV prevention work? If so, why are we not preventing HIV more effectively? How do U.S. efforts to prevent AIDS compare to those of other nations?

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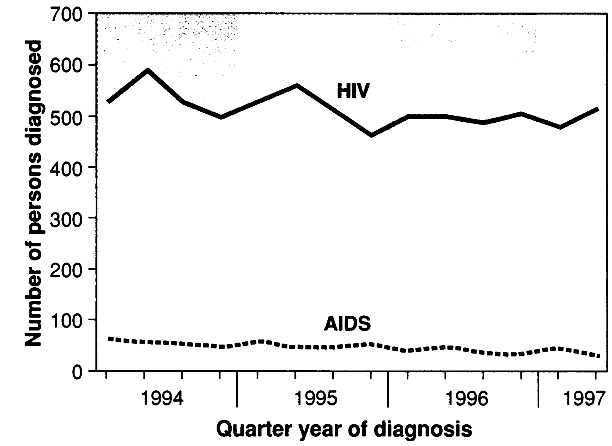

Incidence of AIDS and HIV. Estimated number of persons aged ≥13 years in whom HIV was diagnosed in 25 states in the United States from January 1994 to June 1997 (1).

The answer to the first question is, "Yes—but." The scientific bases for preventive interventions have been strengthened as a result of theoretically based, carefully designed studies that have reasonable periods of follow-up and attention to methods and analytic dimensions. Examples include two well-designed studies discussed in this issue. The first, a research article by the National Institute of Mental Health Multisite HIV Prevention Trial Group on page 1889, focuses on individuals at highest risk for HIV in the United States (2). The second, described in a Viewpoint on page 1873, is an intervention involving societal and countrywide interventions in Thailand (3). Individuals responsible for HIV prevention efforts cannot always act on the results of these studies, because they are unaware of the results or because of barriers in the policy or political arena. One large obstacle in applying research studies to practice has been a reluctance to use scientific findings as a basis for policy because of the perceived political consequences. Three recent examples are (i) reluctance of the U.S. government to permit use of federal funds to support needle exchange programs, (ii) emphasis on "abstinence-only" education, and (iii) controversy about condom advertising.

One effective approach to prevention (2) is an intervention aimed at individuals at highest risk for HIV infection. The method was a randomized controlled study of adults recruited from seven sites across the country, involving 37 clinics, with 1855 people assigned to the control group and 1851 to the intervention, which consisted of seven sessions of small group meetings. Follow-up evaluation was