singlets, the individual diquarks that make up the tetraquark could not exist as free particles. But there's abundant empirical evidence from the spectrum of hadron masses and from scattering phenomena that certain kinds of diquarks are strongly coupled. These favored diquarks are the ones that are antisymmetric under exchange of any of the three quark labels: color, flavor, or spin orientation.

The mesonic-molecule hypothesis is particularly plausible when the mass of the meson in question is very close to the kinematic threshold for decay to a pair of daughters that might be its molecular constituents. And indeed, theorist Jonathan Rosner at the University of Chicago has pointed out that the $Z^{\pm}$ mass is close to the sum of the masses of a particular pair of D mesons that might be forming a mesonic molecule.[3] Every D meson carries a single c (or $\bar{c}$) quark.

University of Rome theorist Luciano Maiani favors the idea that $Z^{\pm}(4430)$ and the other problematic charmonium states are tetraquarks. On that basis, he and coworkers have assigned to each of them a specific diquark–antidiquark bound state and predicted the existence of additional charmonium tetraquarks yet unseen.[4] In particular, they predict that experimenters will find two different neutral siblings of the $Z^{\pm}$ with masses within a few MeV of 4430. That prediction follows from the strict adherence to isotopic-spin symmetry expected of tetraquarks. Mesonic molecules, by contrast, could exhibit significant violation of that approximate symmetry, which is an elaboration of the charge independence of the strong interactions. Maiani and company also predict more distant tetraquark relatives of the $Z^{\pm}(4430)$, with masses up to 4.6 GeV. Some of those, they argue, should have an unusual affinity for decaying into baryon–antibaryon pairs.

Fooled again?

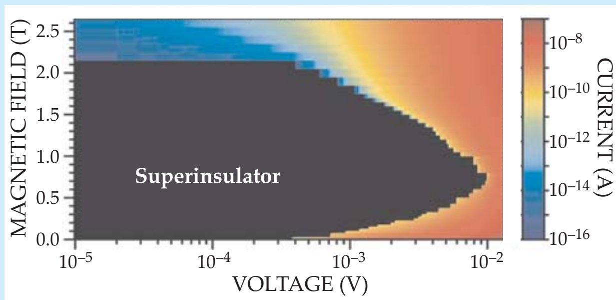
The tetraquark quantum states adduced to account for the observed and predicted charmonium exotics all have the diquark and antidiquark in an *s*-wave state of zero relative orbital angular momentum. Higher orbital states would weaken the already precarious binding. When evidence of the $\Theta^{+}(1530)$ pentaquark baryon was reported in 2003, Wilczek and MIT colleague Robert Jaffe considered that it might be a bound state of two diquarks plus a

physics update

Supplementary material related to these items can be found at www.physicstoday.org.

Giant piezoresistance. A new experiment, conducted by scientists from France, Switzerland, and the UK, has recorded the largest-ever change brought about in a bulk material's electrical resistance by straining the material at room temperature. Called piezoresistance, the phenomenon is often exploited in sensors. In simple metal-foil piezoresistors, the kind used to examine the integrity of a concrete wall or to monitor a prosthetic limb, the change in resistance per unit of strain (a ratio referred to as the gage factor) has a typical value of about 2. For silicon-based piezoresistors, the kind used in cell phones and airbag accelerometers, the gage factor is usually about 100. The new experiment uses a silicon–aluminum hybrid material in which the arrangement of the components, not their composition, is of paramount importance. The metal—in this case aluminum—is effectively a current shunt; applying a mechanical stress to the device deflects current toward or away from the shunt and thereby alters the device's resistance. For appropriate geometric configurations, the researchers, led by Alistair Rowe of the École Polytechnique in Palaiseau, France, measured a gage factor of nearly 900, the largest ever seen at room temperature in a bulk material. Giant piezoresistive structures could be good news for the designers of microelectromechanical devices in which the measurement of ultra-small accelerations or atomic-scale deflections is important. Alternatively, higher sensitivity to movement can be translated into lower power requirements when battery energy is at a premium, as in cell phones. (A. C. H. Rowe et al., *Phys. Rev. Lett.* **100**, 145501, 2008.) —PFS

A superinsulating state. In conventional superconductivity, electrons combine into Cooper pairs, and those pairs collectively enter into a single quantum state in which current can flow with zero electrical resistivity; there is no current dissipation and no Joule heating of the material. A multinational collaboration led by Valerii Vinokur of Argonne National Laboratory in the US and Tatyana Baturina of the Institute of Semiconductor Physics



in Russia recently reported on an analogous but opposite situation in which electrical current is vanishingly small, effectively zero. The group studied a thin film of superconducting titanium nitride. Below critical values of temperature and applied voltage, the system went through an abrupt transition from an insulator with normal, linear resistivity to one with apparently infinite resistivity. What's more, the transition could be crossed by tuning a magnetic field for a given threshold voltage, as shown in the figure. As with a superconductor, the superinsulator has zero Joule loss—but now because there is no current rather than no resistance. The experimental system was successfully modeled and analyzed as an array of superconducting islands or droplets connected by Josephson weak links. The researchers conjecture that such a network is also essential to the superconductor-to-insulator transition in thin films. (V. M. Vinokur et al., *Nature* **452**, 613, 2008.) —PFS

Guiding light. In the pursuit of a quantum computer, the photon is a leading candidate for the quantum bit, or qubit. Working models of photonic circuits, however, have been unscalable arrangements of bulky mirrors and beamsplitters sitting atop a square-meter-sized table. Now scientists at the Center for Quantum Photonics at the University of Bristol in the UK have printed several dozen photonic circuits onto a silicon wafer. The research team created waveguides by first depositing a doped layer of silica onto the wafer, then patterning 3.5-micron-wide ridges into the silica. Two waveguides are coupled when they approach each other and then diverge, as shown in the figure, allowing evanescent waves to overlap. Using such directional couplers, the researchers not only fabricated on-chip beam-