morphology, and distribution of Lewy bodies and neurites in the dopaminergic neurons of PD fly brains does not change even after coexpression of Hsp70 and subsequent neuronal rescue. It is possible that chaperones "detoxify" the protein aggregates in a more subtle way. Alternatively, intracellular aggregates or misfolded α-synuclein may sequester chaperones, depleting intracellular chaperone stores and leaving neurons vulnerable to common environmental stresses. The ability of chaperones to prevent neurodegeneration may explain the diversity of insults associated with an increased risk of this disease, as well as the puzzling protective effect of smoking (*4*). Risk factors may hamper the normal activity of chaperones, thus accelerating neurodegeneration, whereas the oxidative damage caused by smoking may induce a general stress response that increases production of chaperones and inadvertently protects neurons.

Chaperone therapies are already in clinical trials for treating tumors and could be quickly tested for their therapeutic potential in PD. In the brief time elapsed since the first report of α-synuclein mutations in PD patients (*7, 8*), a fly model for PD has been created that can be used for screening potential therapeutics. The work of Auluck and co-workers has revealed one innovative way in which the demise of dopaminergic neurons in PD patients can be arrested and perhaps even reversed.

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PERSPECTIVES: APPLIED PHYSICS

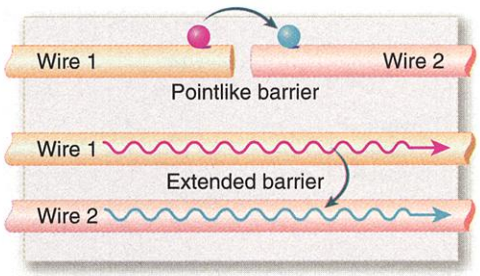
Ultrasmall Wires Get Excited

Ulrich Zülicke

When spectroscopy was invented one-and-a-half centuries ago, it yielded a bonanza of experimental data that revolutionized our understanding of the structure of matter, eventually triggering the birth of quantum mechanics. Since then, ever new and refined spectroscopic tools have enabled quantitative investigation of specimens ranging from the cosmological scale down to the smallest known elementary particle. On page 825 of this issue, Auslaender *et al.* advance the most modern variant of tunneling spectroscopy to have a close look at the dynamics of electrons in ultrasmall wires (*1*). Their results reveal the importance of interactions in low dimensions and allow a glimpse at one of its more exotic consequences: the fractionalization of electrons.

To achieve this goal, Auslaender *et al.* have built an electronic device that allows them to measure the current through a thin but highly insulating barrier between two parallel quantum wires. Defeating the laws of classical physics, electrons as quantum particles are able to tunnel through such an insulating barrier. This is possible because quantum-mechanical wave functions of electrons in the two quantum wires, which are quasi–one-dimensional electronic waveguides, overlap in the barrier. As a result, a finite probability exists for transfer of an electron from one wire through the barrier into the other one.

However, a tunneling process generally costs energy because removal of an electron from one wire and its subsequent addition to the other one excites the double-wire system. The excitation energy must be supplied by an external voltage bias, V. Energy conservation restricts possible tunneling processes to those that leave the double-wire system in an excited state with energy exactly equal to eV, where $-e$ is the electron's charge. The change in tunneling current that results from a small increase in voltage is therefore a direct measure of the number of excitations at this energy. The widespread use of tunneling as a spectroscopic tool is based on this fact (*2*).



Pointlike and extended barriers. The power of Auslaender *et al.*'s experimental setup lies in the ability to create an extended barrier between two wires **(bottom)**. Previous studies could only create pointlike barriers **(top)**.

In previous experiments (*3–5*), tunneling of electrons between quantum wires occurred through pointlike barriers. The feat achieved by Auslaender *et al.* is the fabrication of an extremely uniform extended tunnel barrier between the two parallel wires (see the first figure). In quantum mechanics, every symmetry results in conservation of an associated observable. In the present case, translational invariance along the uniform barrier makes it impossible for electrons to change their momentum in a tunneling event. The requirement of simultaneous conservation of energy and momentum severely restricts the number of possible tunneling processes.

The tunneling constraints in the two-wire device can be illustrated by a simple diagram (see the second figure). The energy of free electrons in a quantum wire depends quadratically on their one-dimensional momentum p, with mass m entering in the proportionality factor: $E(p) = E_0 + p^2/(2m)$. The energy offset E_0 arises from size quantization when fabricating a quantum wire. Energy and momentum of a tunneling electron can be simultaneously conserved at the points where the two parabolas intersect. There is no such point in the left panel of the second figure and, hence, no tunneling current in that situation. A tunneling current can, however, be induced by tuning the voltage and/or an external magnetic field. The spectroscopic power of the experimental setup implemented by Auslaender *et al.* arises from this tunability.

We can account for a voltage bias V in our diagram by introducing a relative shift of the two parabolas in the vertical energy direction by eV. At a certain voltage, the two parabolas overlap and, suddenly, electrons can tunnel while conserving energy and momentum (second figure, middle panel). Monitoring the tunneling current while changing the voltage, Auslaender *et al.* observe a resonance at a particular voltage that corresponds to the difference ΔE_0 between the two wires. No such information would emerge from point-contact tunneling spectroscopy, where the current rises linearly with voltage over a wide range of bias voltages, telling us only that electrons tunnel between two metallic wires.

The effect of a magnetic field B applied perpendicularly to the plane of the two wires is complementary to that of voltage. It can be modeled in our diagram as a relative shift of parabolic dispersion curves in

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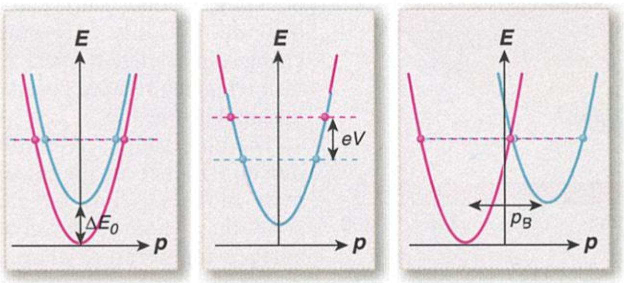
the horizontal momentum direction by p_B. Shifting of dispersion curves in momentum direction by tuning the magnetic field enables their crossing and concomitant current flow (second figure, right panel).

In the double-wire system, voltage bias and perpendicular magnetic field thus turn into convenient experimental knobs for shifting the dispersion curves of the wires in energy and momentum direction, respectively. By recording the voltage and magnetic field for resonant-tunneling conditions, one can obtain a direct image of the electronic excitation spectrum, even when electrons in the two wires interact. Similar momentum-selective tunneling studies were used earlier to investigate spectral properties of two-dimensional electron systems (*6*) and to image electronic wave functions in quantum dots (*7*).

For one-dimensional systems, theory predicts (*8*) drastic changes of the excitation spectrum due to electron-electron interactions. Auslaender *et al.* observe signatures of that. For example, a characteristic broadening of dispersion-curve images at low excitation energies may originate from a truly exotic interaction effect: spin-charge separation. Momentum-resolved tunneling is ideally suited for observing the expected fractionalization of electrons into independent charge and spin degrees of freedom, which, under ideal conditions, would reveal itself in a distinct doubling of tunneling resonances. Further investigations at lower temperature are needed to unambigously attribute the broadened feature to spin-charge separation.



Tuning momentum-resolved tunneling. (Left) Parabolic dispersion curves giving energy *E* as function of momentum *p* for noninteracting electrons in the two wires making up the double-wire tunneling device. The highest energy at which electrons exist in the wires is indicated by broken lines. **(Middle)** A finite voltage bias *V* introduces a relative shift of the two parabolas in the *E* direction by an amount *eV*. Shown is the resonant situation $eV = \Delta E_0$, where both parabolas overlap, enabling electrons to tunnel and conserve energy and momentum simultaneously. **(Right)** Momentum-resolved tunneling can also be enabled by a magnetic field *B*, which shifts dispersion curves in the *p* direction by an amount p_B proportional to *B*.

As fabrication technology progresses at a breathtaking rate, we can expect many more intriguing applications of momentum-resolved tunneling techniques. We may look forward to seeing the results of a momentum-resolved spectral probe of quantum-Hall edge excitations (*9*) and the realization of a proposed spin-filtering device that operates without ferromagnets and magnetic fields (*10*). Momentum-resolved tunneling will continue to serve us in the future as a powerful spectroscopic tool. It may also become the basis for interesting device applications.

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PERSPECTIVES: CLIMATE CHANGE

Tropical Surprises

Dennis L. Hartmann

Earth's climate fluctuates on various time scales, from interannual variations such as El Niño to glacial cycles with time scales of tens of thousands of years. In the global warming debate, knowledge of fluctuations on time scales of decades is particularly important for the detection of climate change and its attribution to natural or human causes. However, relatively little is known about the mechanisms that cause climate variations on these time scales.

Two reports in this issue demonstrate just how little we know. On pages 841 and 838, Wielicki *et al.* (*1*) and Chen *et al.* (*2*) report surprisingly large decadal variations in the energy budget of the tropics. The observations are not easily explained with existing climate models. They may be important for understanding climate stability and predicting the response of climate to human influences such as increasing carbon dioxide concentrations in the atmosphere.

Earth's internal sources of energy are small compared with the energy provided by the Sun. The climate system is therefore in equilibrium when the solar energy absorbed by Earth is balanced by the thermal infrared energy emitted to space from Earth. The relationship between Earth's surface temperature and its energy exchange with space is controlled by the atmosphere. Greenhouse gases such as water vapor and carbon dioxide allow solar radiation to reach Earth's surface but inhibit the transmission of infrared emission from surface to space. Clouds increase the reflection of solar radiation, leading to a cooling of the surface, but also reduce infrared emission to space, thereby warming the surface (*3*). The effects of clouds on the solar and infrared energy fluxes thus tend to partially cancel each other. For tropical convective clouds, this cancellation is often nearly perfect (*4*, *5*).

The carbon dioxide concentration in the atmosphere is expected to double before the end of the 21st century, primarily as a result of coal, oil, and natural gas burning. Surface temperatures are likely to rise as a result, but projections of future climate remain highly uncertain, not least because it is unclear how water vapor and clouds will respond to changes in climate (*6*).

Water vapor is the most important greenhouse gas in the atmosphere and is likely to increase global warming. Its saturation vapor pressure increases exponentially with temperature, resulting in a strong positive feedback between surface warming and a stronger water vapor greenhouse effect.

When water vapor condenses to form cloud droplets, it releases latent heat. This heat drives tropical convection and carries liquid water and ice into the upper troposphere. Evaporation of the cloud water humidifies the atmosphere at high altitudes. Water vapor in the upper tropical troposphere reduces Earth's energy emission

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