tains a summary plot of model forecasts.‡ "Quite a few anticipated the onset, and we had only a few real losers."

The computer models might be doing better, but they haven't won the day yet. Kousky attributes his group's success to "a combination of more experience [watching El Niños develop], 2 decades of research, and the observation network [the National Oceanic and Atmospheric Administration] and NASA have invested in. We look to the models to confirm what we're seeing in our monitoring." What they're seeing now is enough warmth in the central tropical Pacific (a 3-month sea-surface temperature average 0.5°C greater than normal) to justify declaring the early stages of an El Niño. They also see only enough heat stored around the Pacific to anticipate weak-to-moderate warmth this winter. Time will tell. –RICHARD A. KERR

SUPERCONDUCTIVITY

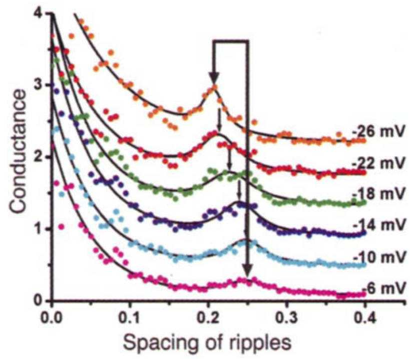
Stripes Theory Beset By Quantum Waves

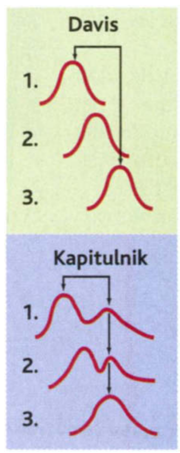
A new explanation of how high-temperature superconductors get their stripes could upend a controversial theory of how some of the materials conduct electricity without resistance. According to the "stripes" theory, electric charges within copper-and-oxygen–based superconductors collect in long lines, and pairs of charges then glide along these stripes unhindered. The scenario recently got a boost when experiments tripled the number of so-called cuprate superconductors sporting these apparent stripes (*Science*, 15 March, p. 1992). But now physicists at the University of California (UC), Berkeley, suggest that cuprate stripes might be an illusion. In a paper published online this week by *Science* (www.sciencexpress.org/cgi/content/abstract/1072640), they show how the stripes in one material might be a subtle effect of overlapping quantum waves of electric charge.

The material is bismuth strontium calcium copper oxide, abbreviated BSCCO and nicknamed bisco. The new results do not rule out charge stripes in BSCCO, but they show that stripes are not needed to explain the undulations earlier researchers spotted on the surface of the material, says Juan-Carlos Campuzano, a physicist at the University of Illinois, Chicago. "These experiments were touted as the proof for stripes," Campuzano says. "Well, that proof will have to come from somewhere else. One does not require stripes to explain the patterns seen in these experiments." Proponents of stripes, however, say the UC Berkeley team's data contain evidence of stripes that the experimenters themselves have overlooked.

On one issue all agree: Those data give the best look so far at BSCCO's electrical properties. To get them, J. C. Séamus Davis and his UC Berkeley colleagues studied the surface of a single crystal of BSCCO with a tiny, fingerlike electrical probe called a scanning tunneling microscope (STM). As they slowly moved the probe across the surface, the current between the tip and the material rose and fell in ripples—a pattern that other researchers had ascribed to stripes of charge lying just beneath the surface.

Going beyond the earlier studies, the UC Berkeley researchers found that as they varied the voltage between tip and surface, the spacing of the ripples changed. That shouldn't happen if stripes were causing the ripples, they argue. Instead, the spacing would stay the same regardless of the voltage—much as the spacing of the pickets in a fence feels the same no matter how hard you press when running your finger over them. Moreover, Davis and colleagues found that the spacing varied just as it would if the ripples sprang from a quantum wave of electrical charge, reflecting off an imperfection in the crystal and then interfering with itself to produce peaks and valleys. They compared their results with data Campuzano and colleagues had taken by another technique, which showed just which wavelengths and energies such waves might have in BSCCO. The two types of data agree nearly perfectly, Davis says.





Peaking through. Bumps on the right signal stripes—if they're there.

Davis acknowledges that stripes might still appear under other conditions—if BSCCO were exposed to a magnetic field, say, or if its composition were changed. But quantum waves explain all the ripples the researchers see in this experiment, he says: "Ockham's razor says that this is all that's necessary."

Yet some researchers argue that the UC Berkeley group shaved away the stripes in its own data. The STM readings also show small signs of ripples whose spacing does not change with voltage, says Aharon Kapitulnik, a physicist at Stanford University in Palo Alto, California, who previously studied BSCCO with an STM and says he saw stripes. In plots where Davis and colleagues see only one peak that moves as the voltage changes, he sees a second that doesn't (see figure). "It's in their own data," Kapitulnik says.

Steven Kivelson, a physicist at the University of California, Los Angeles, thinks both waves and stripes might be playing a role. Contrary to what Campuzano's data predict, Kivelson says, the spacing of Davis's ripples appears to stop changing as the voltage between tip and sample decreases toward zero. That suggests the wave phenomenon fades and stripes emerge at very low voltages. If such subtle signs of stripes are there, Davis and colleagues should find them as they push forward with their technique.

Meanwhile, a fresh challenge to the stripes model comes from a different direction. On page 581, Peter Abbamonte and colleagues at the University of Groningen in the Netherlands and Oxxel GmbH in Bremen, Germany, report a new x-ray scattering technique that should be especially sensitive to charge stripes. The researchers zapped a film of superconducting lanthanum copper oxide (LCO) with x-rays tuned so they'd be absorbed in regions where the LCO contained extra electrical charge. That would cause the x-rays to reflect in a way that revealed the presence of charge stripes. The researchers saw no evidence of such an effect.

Unfortunately, the samples Abbamonte and colleagues examined are not quite like the other lanthanum-based materials that have already shown their stripes, says John Tranquada of Brookhaven National Laboratory in Upton, New York. Thus it's hard to know whether there should have been stripes for the Dutch-German researchers to see. "Because it's a new technique, it would be useful to calibrate it on one of the exact same materials where we have evidence for stripes," he says. Abbamonte, now at Cornell University, says he's currently trying to do just that by studying samples in which Tranquada spotted stripes in 1995.

Even if all cuprate superconductors have stripes, physicists still have to determine whether they really work the way the stripes theory predicts, Tranquada says. That could be an even tougher job than reconciling contradictory results and interpretations of the data, and it might keep physicists reading between the lines for some time to come.

–ADRIAN CHO

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