ence in Rehovot, Israel, presented the results of their studies of the Hall voltage near the $\nu = 2$ filling factor. Like the Berkeley–Stanford collaboration, Yacoby and his colleagues find that the voltage drop is linear when the magnetic field is far from the $\nu = 2$ state, but there the similarities stop. The Bell Labs data suggest that, as the field passes through the Hall plateau, there is a strong voltage drop near the edges of the channel and almost none in the center. Under certain conditions, the experimenters see other nonuniform Hall voltage distributions that suggest more complex Hall current distributions.

What does the structure mean?

The smallest length scale of interest in measurements of a two-dimensional gas is the distance between electrons (which is considerably larger in these low-density systems than the interatomic distances commonly imaged by scanning probes). Allan MacDonald of Indiana University commented to us that the ideal two-dimensional gas has no structure on this scale. Thus, the spatial variations seen in both the compressibility and Hall voltage measurements reflect the influence of either the disorder potential, caused by impurities in the underlying semiconductor, or the proximity to the edges of the sample. It would be quite intriguing, according to MacDonald, if the patterns seen in the recent experiments, or in future images made with similar techniques, were related to the fractal wavefunctions that occur in some theoretical models of the quantum Hall electrons in random potentials.

The spatial resolution in these scanning probe microscopies can be no finer than the depth of the two-dimensional gas below the surface. To improve on the spatial resolution of images below the surface, researchers from Harvard and the University of California, Santa Barbara are trying to bring the two-dimensional layer closer to the surface, but they note that it's hard to get it closer than 25 nm. This group is using low-temperature scanning probe microscopy to study current flow through subsurface ballistic point contacts.[7]

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References

1. S. H. Tessmer, P. I. Glicofridis, R. C. Ashoori, L. S. Levitov, M. R. Melloch, Nature **392**, 51 (1998).
2. A. H. MacDonald, T. M. Rice, W. F. Brinkman, Phys. Rev. B **28**, 3648 (1983).
3. K. Tsemekhman, V. Tsemekhman, C. Wexler, D. J. Thouless, Solid State Commun. **101**, 1879 (1997); C. Wexler, D. J. Thouless, Phys. Rev. B **49**, 4815 (1994); D. J. Thouless, Phys. Rev. Lett. **71**, 1879 (1993).
4. M. J. Yoo, T. A. Fulton, H. F. Hess, R. L. Willett, L. N. Dunkleberger, R. J. Chichester, L. N. Pfeiffer, K. W. West, Science **276**, 579 (1997).
5. R. Knott, W. Dietsche, K. von Klitzing, K. Eberl, K. Ploog, Semicond. Sci. Technol. **10**, 117 (1995).
6. T. A. Fulton, G. J. Dolan, Phys. Rev. Lett. **59**, 109 (1987).
7. M. A. Eriksson, R. G. Beck, M. Topinka, J. A. Katine, R. M. Westervelt, K. L. Campman, A. C. Gossard, Appl. Phys. Lett. **69**, 671 (1996).

Energy Budget of Deep-Focus Earthquakes Suggests They May Be Slip-Sliding Away

The mystery of what initiates earthquakes in Earth's mantle is as deep as ever, but the energetics of these events may help provide answers.

To understand why the Bolivian earthquake of 9 June 1994 has so rapidly become one of the most thoroughly studied seismic events in history, one must know a little about both the event and the significance of when and where it occurred. (See PHYSICS TODAY, October 1994, page 17.) To begin with, the Bolivian quake occurred in the mantle, nearly 640 km beneath the Amazon basin east of the Andes. Such a large "deep-focus" earthquake—and this one, with magnitude 8.3, was the largest such event ever recorded—can make the planet ring like a bell, exciting overtones of Earth's normal modes of oscillation that are sensitive to inhomogeneities in the core and mantle. Add in the fact that the Bolivian quake occurred after the deployment of several global and local networks of high-quality digital seismological stations, and it becomes clear that the quake offered researchers an unprecedented opportunity to illuminate the three-dimensional structure of Earth's mantle and core. (See the box at right.)

However, even as the seismographic record of the quake was illuminating the structure of Earth's interior, it was challenging prevailing ideas of how earthquakes can occur in the mantle. The mechanism of shallow quakes—brittle failure—will not work in the mantle, because high temperatures and pressures render rock more likely to flow than to fracture in response to stress. The mechanism of deep-focus earthquakes has remained mysterious since they were first discovered by the Japanese seismologist Kiyoo Wadati in the 1920s.

Because deep-focus earthquakes occur in regions where a slab of cold oceanic plate is being forced down—subducted—into the hot mantle, current theories seek to explain deep seismicity in terms of the changes undergone by minerals in the slab as it is heated and compressed during its descent into the mantle. (See the box on page 20.) The Bolivian quake posed significant challenges to any candidate mechanism,[1] because it involved a rup-

Terrestrial Tomography

To researchers who use Earth's normal modes of oscillation to map the three-dimensional structure of the planet's interior, the good fortune of having the largest-ever deep-focus earthquake occur just after the deployment of global broadband seismographic networks seemed like a dream come true. It was certainly no dream, though, and computers have been crunching data ever since. Barbara Romanowicz, Xiang-Dong Li and Joseph Durek (University of California, Berkeley) used normal modes excited by recent large deep-focus quakes in Bolivia and elsewhere to characterize the anisotropy of Earth's inner core.[3] Michael Ritzwoller and Joseph Resovsky[4] (University of Colorado at Boulder) and Jeroen Tromp and Xiong He[5] (Harvard University) used data from several recent deep-focus earthquakes to show that normal-mode studies can yield improvements in three-dimensional models of Earth, especially for the planet's mantle.

According to Ritzwoller, this work is just the beginning. "To this point, normal mode data have been well mined only up to a frequency of 3 millihertz. There is probably a factor of six more data at frequencies below 10 mHz that remain to be analyzed." A task of that magnitude ought to keep normal-mode researchers busy until the next really big deep-focus earthquake—and maybe longer.