two ways; only one of the two interpretations identifies the quasiparticles in the $^2/_3$ liquid as having a charge of $^1/_3 e$.

—ANIL KHURANA

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EARTHQUAKE JOSTLES THE NEW STANFORD LINEAR COLLIDER

On 12 October the Stanford Linear Accelerator Center announced its finding that Nature has only three families of elementary particles.[1] (See PHYSICS TODAY, October, page 17) Five days later, as if in anger at having its secret revealed, Nature shook the offending instrument—the recently completed Stanford Linear Collider—by the throat. All things considered, the SLC has suffered relatively little damage from the historic earthquake that struck the San Francisco Bay area at 5:04 pm on 17 October. Still, the small misalignments caused by the quake have interrupted the physics schedule of the collider for more than a month. As of this writing, the fond expectation at SLAC is for "a few more Z^0"s by Christmas."

The earthquake occurred one day after the beginning of a scheduled collider shutdown, during which vertex detectors were to be installed in the large Mark II detector that surrounds the point where the accelerator's electron and positron beams collide. The quake, whose epicenter was some 30 miles south of SLAC in the Santa Cruz mountains, shook the laboratory violently for 15 harrowing seconds. As SLAC spokesman Michael Riordan described the scene, "People dashed for doors or dove under desks to avoid the hail of books, ceiling tiles and other falling objects. Physicists standing on top of a teetering endcap of the partially assembled SLD detector [which will eventually replace the venerable Mark II] clung to its railing, hoping that this 50-foot-high upright iron slab would not topple to the concrete floor. A hapless technician suspended in a bucket from the overhead crane swung helplessly above the gaping pit as the hundred-ton crane rocked back and forth in its tracks."

But the SLAC Earthquake Safety Committee had done its job well. Aside from a few cracks and leaks there was no major gross damage, and no one was injured. The proper functioning of the Stanford Linear Collider, however, depends on the very precise alignment of its two-mile-long linac, with tolerances on the order of 100 microns, and on equally precise positioning of the bending magnets in the two great arcs that bring the electron and positron beams from the end of the linac into head-on collision. Though there were no gross disruptions to be seen in this complex array of rf cavities and magnets after the quake, there were clearly a number of small displacements that would have to be put right before the SLC could resume doing physics.

High-energy geology

The linac rests on bedrock, except for a small region of fill, where subsidence had been observed in the past and dealt with by means of built-in jacks. The laser-beam survey undertaken after the quake found a $^1/_2$-cm dip in this fill region. That was straightened out in short order. More surprisingly, a shift of about 1 cm was found near the downstream end, in a place where the linac sits on 25-million-year-old Miocene sandstone. Nearby, there were fresh cracks in the wall. "We had rediscovered an obscure hairline fault," Riordan told us. "This is the first time anyone has done geology with a high-energy linac."

At this fault line, the end of the linac, together with the entire SLC arc structure, had in fact shifted by more than a centimeter relative to the rest of the linac. The distorted linac sections had to be reconfigured into a smooth curve. Nonetheless, four weeks after the earthquake, electron and positron beams were once again emerging from the linac into their respective collider arcs with emittances (the product of the spatial and angular beam spreads) back down to pre-quake levels.

These beams were indispensable for surveying the arcs, whose horizontal and vertical undulations make lasers useless. With the 50-GeV electron and positron beams showing the way, many of the bending magnets in the arcs were realigned. By mid-November, the positron beam was coming all the way through the south arc to the final straight section where the beams collide. The electron beam in the north arc, however, was getting lost about a third of the way down the arc. The search for the missing beam turned up yet another fault, which had shifted magnets by about a centimeter. This time the SLC had made a real contribution to geology: The second fault was unknown before the errant electron beam pointed the way.

With the arc magnets realigned early in December, both beams were emerging from their downstream arc ends into the 200-meter final straight section with beam quality almost back to normal. In this final section, where the beams are focused down to 3-micron spots at the collision point, alignment tolerances are comparably stringent. Here optical surveying is of little use; one needs precision beam monitors to see if the final-focusing quadrupole magnets have moved a few microns. This last bit of surveying was expected to be completed by mid-December. If the final quadrupoles have indeed shifted by as much as 10 microns, a new collision axis might have to be set up, delaying the resumption of the Z^0 harvest by another week.

Santa Cruz

Elsewhere in the San Francisco Bay area, the Lawrence Laboratories at Berkeley and Livermore suffered little damage. The Santa Cruz campus of the University of California, just 10 miles west of the epicenter, was less fortunate. The physics department's office, classroom and laboratory building suffered the worst damage of any major structure on the campus. Chunks of broken concrete testified to the severe stresses the building had endured in the quake. It had to be closed to students and staff for two weeks, until its concrete pillars had been shored up with 200 timbers. Longer-term measures to assure the building's safety are still being assessed.

Equipment damage in the building's laboratories was, by comparison, relatively minor—a few hundred thousand dollars worth. "It wasn't all bad," recalls physicist Donald Coyne. "When the building was closed we had to hold colloquia in the university theater. Somehow, talks on the standard model sound better from behind the footlights."

—BERTRAM SCHWARZSCHILD

Reference

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