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China Pursues Major Role in Particle Physics

By DENNIS OVERBYE

Mao Zedong dreamed of splitting an electron.

This was no idle diversion. According to natural dialectics, which formed the philosophical underpinnings of Marxism, the entire universe, from top to bottom, was seething with tension and change. As a result, Mao thought, nature should be infinitely divisible.

“Take a footlong stick and remove half every day. In 10,000 years it will not run out,” Mao, who rarely missed the chance to chat up physicists, often said. “This is truth. If you don’t believe it, you may test it. If there is an end, there is no science.”

Suitably inspired by such thoughts, in the 1960s Chinese physicists invented a sort of onion-layer theory of particles called the straton model, in which both protons and electrons have a common constituent. Sheldon Glashow, the physicist and Nobelist now at Boston University, once suggested that such a particle, if found, should be named the Maon.

But Mao’s Cultural Revolution, which was unleashed in 1966, closed universities and journals and set back Chinese physics for a generation. In the meantime, quarks beat out Maons as the constituents of protons. To this day the electron remains undivided.

Mao’s enthusiasm for particle physics nevertheless left a legacy.

Ever since 1989, in a collection of buildings occupying about a city block in Beijing, Chinese physicists have been quietly shooting electrons and their evil-twin opposites — positrons — around a 80-yard-diameter underground track at nearly the speed of light, and then banging them together in little fireballs of energy.

Over the years, the work at the Beijing collider has produced results that are critical to efforts on the frontier of particle physics at more famous and much larger accelerators — those that have racetracks miles around and trillion-electron-volt energies, like the Tevatron at the Fermi National Accelerator Laboratory, known as Fermilab, outside Chicago, and the Large Hadron Collider, scheduled to open next year at the CERN laboratory near Geneva.

Next fall, the Beijing collider, which is shut down for a major upgrade, will be reborn with the ability to produce 100 times as many collisions it did before, enabling physicists to investigate the quantum property called charm and resolve some standing puzzles about quarks.

By the end of the decade, as the world's physicists shift their attention and money to the new CERN collider, experiments at the Stanford Linear Accelerator Center in Menlo Park, Calif., and the Fermilab are expected to shut down. The Beijing collider then will be one of the few other particle accelerators still doing physics experiments left in the world, and Chinese physicists are trolling for collaborators.

"Although collaborations are still modest, golden physics opportunities exist in China," Hesheng Chen, director of the Institute of High Energy Physics in Beijing, recently wrote in the physics magazine Symmetry.

More important, Chinese particle physicists are poised to make a major contribution to one of the grandest collaborations of all, a proposed giant accelerator called the International Linear Collider, or I.L.C. The world's physicists have already determined that it will be the Next Big Thing, but how many billions it will cost and where it will be built have yet to be decided.

Still in planning stages, the linear collider would be designed to carry international research beyond any new laws of physics and forms of matter that may be discovered using the new machine at CERN.

"China is certainly interested in the I.L.C.," said Dr. Chen, who is a member of the steering committee for the international collider, and one of the organizers of a meeting this week in Beijing, where Chinese scientists and industry and government leaders will start talking about what role to take in the project.

Jie Gao, a physicist at Beijing's Institute of High Energy Physics and a member of the big collider's design team who helped instigate this week's meeting, said he hoped the conclusion was positive, "for the good of sciences, economy, education, a harmonious and peaceful world, and a sustainable development of human being."

It wasn't until the early 1970s, after the turmoil of the Cultural Revolution began to wind down, that Chinese physics began to recover. Zhou Enlai, China's premier, took advantage of Mao's enthusiasms to endorse the development of high-energy physics, including a long-dormant dream of building a Chinese particle accelerator. It didn't hurt that particle physics was closely connected to nuclear weapons.

Zhou got support from so-called overseas Chinese scientists, who had begun to visit their homeland in droves, like Chen-Ning Yang, then of Brookhaven National Laboratory in Upton, N.Y., and Tsung-Dao Lee, of Columbia University, who were Nobelists and heroes in China, and who talked up the importance of basic research to Mao and others.

A group of Chinese physicists toured Western laboratories in 1973 and returned with their hearts set on building a collider that would bang protons together at energies of 50 billion electron volts. When Wolfgang Panofsky, the former director of the Stanford accelerator, first visited China in 1976 in the wake of the Tangshan earthquake that killed hundreds of thousands, and after the deaths of Mao and Zhou, he was struck by the desire of the Chinese people to carry on, even though many were living in tents in the streets.

But Dr. Panofsky and others, including Dr. Lee, argued that a more modest machine would serve China better.

“We talked them out of it,” Dr Panofsky said. In 1982, in the midst of economic difficulties, the proton machine was canceled in favor of one that would collide electrons and positrons at the much lower energy of around 2 billion electron volts. Such a machine would produce synchrotron radiation, which has medical and other uses as well as a role in particle research. The site of the accelerator was also moved from a remote area outside Beijing near the Ming tombs into the city.

President Deng Xiaoping himself showed up to shovel dirt at the groundbreaking.

Dr. Panofsky remembered being in Beijing for a presentation on physics and the collider.

“Deng shut us up and gave an hour-and-a-half lecture on the beauty of high-energy physics,” Dr. Panofsky said. To learn the business, a group of Chinese accelerator engineers spent a summer at the Stanford accelerator.

“It was quite a scene,” Dr. Panofsky recalled. “We had 30 Chinese engineers in Mao suits running in and out of our lab.” It only took four years, an astonishingly short time, to build the Beijing collider.

“It was finished on time and on budget,” said Dr. Chen, who had returned to China from the Massachusetts Institute of Technology in the 1980s to work at the physics institute. where he became director in 1998. The size of the Beijing collider was based on what could be achieved at the time, but it turned out to be a fortuitous choice.

“The energy was lower but it was more interesting,” Dr. Chen said.

Particle colliders get their oomph from Einstein’s famous equivalence of mass and energy. The more energy they can pack into those tiny fireballs, the closer physicists approach the conditions of the Big Bang itself, and the more massive and strange particles can be created — as permitted by the laws of physics prevailing at those temperatures and times.

New particles, heralding perhaps new laws, are often first glimpsed by the mighty proton colliders. But such collisions are intrinsically messy and hard to understand because of all the junk that lives inside protons, and physicists often leave new particles behind and unstudied in their rush to build the next bigger machine and, in effect, go farther back in time.

The energy range of the Beijing collider, 1 to 2.2 billion electron volts per beam, contained a lot of puzzling left-behind physics, including the tau, a sort of superfat electron, for which nature has no obvious purpose, and the so-called J/psi. The J/psi, consisting of a pair of quarks each exhibiting the quantum property known whimsically as charm, set off a revolution and led to Nobel prizes when it was discovered in 1974.

“There is a lot going on in that energy region,” said Frederick A. Harris, a professor of physics at the University of Hawaii, who works often at the Beijing collider. By tuning the energy of their colliding beams, the Chinese researchers have been able to measure the mass of the tau very precisely, as well as carry out detailed studies of the J/psi and similar particles.

In the collider’s energy range, Dr. Chen said simply, “We dominate.”

Among the collider’s achievements, Dr. Harris said, was the most precise measurement yet of a number called “R.” In the so-called standard model, which currently rules particle physics, this parameter measures the likelihood of fireballs produced in the collider to materialize into so-called hadrons, particles made of quarks as opposed to other, simpler particles known as muons. That involved “changing the machine energy 91 times,” explained Dr. Harris.

When physicists at CERN fire up their new Large Hadron Collider, which will eventually collide protons with 7 trillion electron volts of energy, in search of new particles and clues to new unified laws of physics, the Beijing data on this parameter will be critical to their analyses.

“They are all dependent on measurements made in China at lower energy,” Dr. Harris said.

Dr. Panofsky, of the Stanford accelerator, said: “Most economic growth is not due to new invention, but making things faster and cheaper. High energy physics mirrors this. In China they measure things known to exist better and with higher accuracy than in the West.”

The improvement of the Beijing collider will extend the Chinese hegemony over this energy range, allowing the experiments to gather 100 times more data on rare events.

Recently, there has been a flurry of sightings at other particle experiments of other particles made of multiple quarks, including a proton and antiproton stuck together to make a six-quark particle first predicted by the Italian physicist Enrico Fermi in 1948. Confirmation of the existence of such particles would be an important clue for theorists who try to navigate intractable equations to calculate the properties of quarks.

“Do they exist or not?” Dr. Panofsky asked. “Tune in next year.”Completing the Beijing improvements, Dr. Chen has said, will also free Chinese accelerator experts to concentrate their energies on the international effort to build the proposed International Linear Collider some time in the next decade.

The proposed I.L.C. would shoot electrons and positrons at each other with 500 billion electron volts of energy through a tunnel 20 miles long. An approximate price tag will be announced when the international collider planning team meets in Beijing this February.

Since this collider is being planned to follow up on discoveries made at CERN, and is likely to cost several billion dollars, it probably won't be approved by the governments that would have to do the heavy financial lifting until the end of the decade — when the new CERN collider has something to show for itself.

"The I.L.C is still a mythical beast," Dr. Panofsky said.

Yet the jockeying for where to put the machine has already begun. The host country for the collider would have the advantage of being the center of 21st-century physics, but would have to bear a larger share of the cost.

Last spring, a report from the National Academy of Sciences urged the United States to do what it takes to get it built here rather than in Europe or Asia, or face the prospect of relinquishing traditional leadership in physics.

Barry C. Barish, a California Institute of Technology physicist who is head of the design team for the international collider, said the "informal plan" is for China's role to grow in the coming years. Just how much depends on what kind of commitment the Chinese government decides to make.

Dr. Harris said, "The rate China is growing, this is something they could contemplate hosting in 10 years." Although few accelerator experts expect China to be that aggressive, nobody really knows what the future holds. Given the explosive growth of China's economy and the vow of the country's leaders to emphasize science and technology, it is natural to wonder whether some future particles will have Chinese names the way many of the bright stars in the sky have Arabic names. Thanks to the Beijing collider, said Dr. Chen, "A new generation of accelerator engineers and data engineers is growing up."

It has helped them that "now a person can have a reasonable life if you are interested in science," said Dr. Chen, who spent part of the Cultural Revolution years as a high school teacher.

A middle generation of scientists have returned from the diaspora to pitch in. Among them is Dr. Gao, who came back to China a couple of years ago after spending 15 years in France. He is leading the design of the so-called damping rings that will keep the particle beams of the international collider tightly focused. Dr. Gao said he was struck by the pace of life in today's China.

"Another big surprising change is that all Chinese are very busy in all fields, the work is busy and the life is busy," Dr. Gao said. "I am terribly tired, but very happy, there are too many things to learn, to do and to improve."