Nobel laureate Burton Richter to speak about future of particle physics

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Particle physics is about to transform our thinking once again. Experiments of the last 15 years suggest new forms of matter, new forces of nature and perhaps even new dimensions of space and time. Pinning down the new ideas will require more data from larger and more expensive machines-at a time when funding is more difficult than ever to secure.

"As Dickens wrote, it is the best of times and the worst of times," says Nobel laureate Burton Richter, the Paul Pigott Professor in the Physical Sciences, Emeritus, at the Stanford Linear Accelerator Center and a pioneer of the particle colliders that now dominate high-energy physics. "We are in the midst of a revolution in understanding, but accelerator facilities are shutting down before new ones can open, and there is great uncertainty about future funding."

On Feb. 16, at the annual meeting of the American Association for the Advancement of Science in San Francisco, Richter will speak about the future course for elementary particle physics. He will offer a short overview of current research and explain his view of the most important opportunities for the field today.

Over the last 15 years, physicists discovered that they understand much less of the universe than they thought. No longer do they believe that luminous matter alone fills up the vacuum of space. Instead, two mysterious substances-dark matter and dark energy-comprise 96 percent of the universe. Neutrinos, very light elementary particles that stream from the sun, change from one type of matter to another as they travel close to the speed of light. And the Standard Model-the theory once believed to describe all fundamental interactions-no longer describes all that we observe.

The next 15 years are likely to answer some questions and raise new ones, Richter says. Physicists hope to find what is beyond the Standard Model, what at least some of the dark matter is made of and what is driving the accelerating expansion of the universe. The next few years may even see an experimental test of theories that posit more dimensions than just three of space and one of time, including string theory.

Yet none of this can happen without new experiments and new machinery, Richter says. In choosing which experiments to fund, the particle physics community must make choices that will severely limit the pace of discovery in some areas.

"This is a time where we cannot afford the merely good, but must focus on the really important if we are to continue our quest to learn what the universe is made of and how it works," Richter says.

In the lecture, Richter will present his views on which experiments must be funded and which will have to wait. Specifically, he will discuss the Large Hadron Collider (LHC), the proposed International Linear Collider (ILC), the need for accelerator research and development, the Joint Dark Energy Mission (JDEM) and Large Synoptic Survey Telescope (LSST) astroparticle experiments, and the critical questions that must be addressed regarding neutrinos.

The experiments

The LHC, now under construction at the European Laboratory for Particle Physics (CERN), will begin colliding protons at the end of this year. Researchers hope this machine will finally reveal the Higgs boson, a particle theorized to give mass to matter. The LHC also may discover whether particles have supersymmetric partners and determine if extra dimensions exist, among other things.

If built, the ILC would offer a more detailed perspective of what the LHC finds. By colliding electrons and positrons at higher energies than ever before, the machine would allow physicists to see new particles in unprecedented detail. Experiments at the ILC also could help explain the dominance of matter over antimatter in the universe by exploring "charge-parity violation," an asymmetry between the behavior of matter and antimatter, and could identify the particles predicted by theories of supersymmetry and extra dimensions. If the LHC turns up nothing, however, it is unlikely that the ILC will get built, Richter says.

Searches for dark matter and dark energy underground, on the Earth's surface and in space also will be an essential element of progress, Richter says. This area includes JDEM, a space-based instrument to search for supernovae, and LSST, a ground-based telescope that will provide digital imaging of faint astronomical objects across the entire sky.

In the coming years, various neutrino experiments with reactors, accelerators and cosmic rays may even offer insight into charge-parity violation.

"There's a huge opportunity here," he says. "While we may not be able to do all of this as fast as we would like, we need to get the really important done even if it takes longer than we would wish. The results will tell us much more about the universe and how it works."

Also speaking at the session are Nobel laureate David Gross of the University of California-Santa Barbara (matter, space and time); Young-

Kee Kim of the University of Chicago (today's particle physics frontier); Philip Bryant of CERN (the LHC); Albert De Roeck of CERN (the LHC); and Jonathan Bagger of Johns Hopkins University (the ILC).

Source: Stanford University