Bullish on Particles

Particle physics was, until recently, the flagship of U.S. physics, if not U.S. science. With ever larger “atom smashers” and such charismatic figures as J. Robert Oppenheimer and Richard Feynman, the field attracted the best and the brightest. These U.S. scientists garnered Nobel Prizes and public fame, becoming academic leaders and government advisors. The close association with national security that grew out of the Manhattan Project guaranteed both prominence and funding priority. But in 1993, the perfect storm hit: The $10 billion Superconducting Super Collider was canceled, the Cold War ended, and life sciences rose to prominence. Since then, we’ve seen flat budgets, more canceled projects, and no firm prospects for high-energy accelerator experiments on U.S. soil after 2009. In today’s “flat world” where technology has made science around the world tightly interconnected, the future of particle physics everywhere can be no brighter than it is in the United States, and that future looks dark.

Despite this, I am bullish on the future of U.S. particle physics, and my reason is simple. Right now, the field is poised for breakthroughs as stunning as those that followed Einstein’s annus mirabilis 100 years ago. The focus has shifted from searching for the smallest subatomic seed to understanding the universe and the nature of matter, energy, space, and time. Big questions are ripe for answering. What is the “dark matter” that holds our galaxy together? Where did space and time come from, and how many space-time dimensions are there? How did the universe begin, and what is the mysterious dark energy accelerating its expansion? And perhaps the biggest question of all, one whose answer probably underlies all the others: How are the two pillars of modern physics—quantum mechanics and general relativity—to be reconciled and a unified understanding of the forces of nature achieved? Particle physics is on the verge of something really big, as if the past 50 glory years were just preparation.

As exciting as these opportunities are, the challenges are great and morale in the U.S. particle physics community is low. With its link to national security severed, particle physics must now compete for funding and students with other fields that also have exciting agendas—from astrophysics and genomics to computer science and biophysics. Telescopes and underground laboratories to study dark energy and dark matter are now as essential as accelerators, making planning more complicated and the cost of discovery higher. And all of this in a time of constrained budgets for all science.

As a U.S. scientist, I can’t imagine the United States not taking part in the grand scientific adventure ahead. Moreover, a reality of the flat world is that the field’s big dreams will go unrealized if particle physics can’t right itself in the United States. Three things are essential to correct the situation. If particle physics is to be successful in garnering the needed funding and attracting the best people, the field must lead with a broad scientific agenda, rather than defining itself by big atom-smashers as in the past. Hosting a $5 billion electron-positron linear collider to follow the Large Hadron Collider now being built in Geneva would bring high-energy physics back to the United States and make a strong statement of U.S. commitment to this field, but it must be the science, not merely the desire to reclaim the energy frontier, that dictates whether to push forward with such an endeavor. There must also be a commitment to diverse approaches. Recent discoveries (dark matter, dark energy, and neutrino mass) remind us that other tools are just as essential. Finally, particle physics must achieve unprecedented (for any field) global coordination. Many of the critical projects on the path to answering the big questions exceed the financial resources of any one country or region. A strong national presence must be balanced against a strategic global program. Not every facility can be located here, and a new strategy of U.S. leadership must replace the old strategy of U.S. dominance.

In their zeal to explore the world of the unimaginably small, particle physicists have repeatedly shown that they can blaze new trails and overcome formidable barriers. I am willing to bet that particle physicists in the United States and around the world will come through again. With unprecedented opportunities for revolutionary breakthroughs, all of science should be pulling for them.

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