Physics in 50 Years

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Physics Today invited me to talk about the future of physics at its fiftieth-anniversary celebration. Overcome by the desire to see old friends and the promise of good food and drink, I agreed.

Let me start by expressing my pleasure in participating in Physics Today’s fiftieth-anniversary celebration, and expressing my deep appreciation to Charles Harris, Steve Benka and Gloria Lubkin for providing me with this evidently irresistible opportunity to humiliate myself publicly by attempting to say something intelligent about physics in the next fifty years.

As everyone knows, long-term predictions in science are hopeless and even short-term predictions are usually wrong. Fortunately, they are usually wrong the right way, for in physics—unlike the common situation in human affairs—reality frequently exceeds expectations. I documented this phenomenon some years ago in a Physics Today “Reference Frame” column (“A Lesson in Humility,” December 1991, page 9), showing that if one compares the best forecasts made by a group of responsible scientists with what actually happens, the forecasts are pale compared to the reality. The particular group of responsible scientists was the Physics Survey Committee, headed by William Brinkman, which prepared a report in 1986. Looking back on our omissions five years later, I found the following unpredictable discoveries and overlooked advances: Supernova 1987A, high-temperature superconductivity, atom cooling and laser manipulation, buckyballs, complexity, chaos and nonlinear dynamics, superdeformed nuclei, large-scale structure of the universe and mesoscopic physics.

In my own field of atomic, molecular and optical physics, there was such rapid progress after the Brinkman report that a new committee set out to prepare an up-to-date survey. The result, Atomic Molecular and Optical Science (National Academy Press, 1994), was about as up-to-date as possible. Nevertheless, it gave little inklings that the most exciting advance in atomic physics for decades was about to take place—Rose-Einstein condensation in a gas. Another missed topic was quantum computation, which was a hot topic within a couple of years. Such omissions are not due to lack of imagination or shortsightedness. If any blame is to be assigned, it must be assigned to Nature for being too generous.

Progress in technology ought to be easier to forecast than discoveries in basic science, but even here the predictions are likely to be askev. One of my favorite childhood books was a 1912 edition of the Book of Knowledge. There was a splendid article on the latest technical wonder, the airplane, with a full page devoted to illustrations of the airplanes of the future. They were not mere biplanes. They were triplanes, quadraplanes, and airplanes with up to a dozen wings. And at the 1939 World’s Fair, the General Motors Futurama displayed a gorgeous model of teardrop-shaped cars whizzing through pristine cities on highways with fantastically complex intersections and overpasses. The Futurama actually provided a pretty good picture of today’s highways, but thanks in large part to automobile emission, the cities are hardly pristine, and the cars, of course, are not whizzing at high speed—much of the time they are crawling bumper to bumper.

In spite of the obvious pitfalls of prediction, there is a long and honorable tradition of physicists misforecasting scientific progress. Toward the end of the 19th century, physics was so impressive that some respected physicists thought the job was pretty well finished. Oliver Lodge stated that “if you are really smart, in 1900, he presented a lecture at the Royal Institution entitled “Nineteenth Century Clouds over the Dynamical Theory of Heat and Light.” He spotted two clouds. Cloud one was the problem of specific heats: He emphasized that the equipartition theorem gave incorrect values for specific heats of molecules unless one arbitrarily excluded certain motions. He characterized both of these clouds as being pretty dark, and of course he was right. Nevertheless, even Kelvin had no way to foretell the revolution about to take place.

Since it is essentially impossible to predict scientific discoveries, it is tempting to go in the opposite direction and predict things that will not happen. However, this is also most unwise, since it practically guarantees that they will happen. Perhaps you have your own pet list of failed predictions. On my list are Rutherford’s claim that anyone who thought nuclear energy would be useful was talking moonshine, and the prediction made to Charles Townes that the maser would never work—this by some respected physicists at Columbia. I recall a talk at an American Physical Society meeting by President Reagan’s science adviser, George Keyworth, shortly after the President announced the Strategic Defense Initiative whose technical goal was an impenetrable missile defense. There had been much opposition from the scientific community, and to counter that Keyworth produced a long list of things that experts said could not work but eventually did work, from airplanes to telescopes.
vision. The argument appeared to be that because so many experts said SDI was not technically possible, we should be assured that it was technically possible. Unfortunately, we can't be absolutely sure that universal disapproval by experts guarantees success.

So, I will refrain from predicting what will not occur in the future. Further, I won't even hazard a guess about which fields will decline, for my own absolutely sure that universal disapproval was not technically possible, we should be absolutely sure that universal disapproval would not even happen in physics, I appear to have figments as natural and intuitive, and they may well use a language that we could not honestly accept a quantum description as being quantitative. Lots of people, myself included, expect that physics will have increasingly probabilistic behavior—radioactive decays— were deeply troubling. Today, most physicists regard quantum descriptions as natural and intuitive, and they are not at all troubled by the language of probability. Lots of people, myself included, expect that physics will have increasingly important things to say about biophysical processes, but the language of that physics may turn out to be different from the language we know. And if physics comes to deal with large complex systems by which I mean something neurological, possibly the brain of a fruit fly or something like that, it may well use a language that we could not accept today as being quantitative, just as a turn-of-the-century physicist could not honestly accept a quantum description as being quantitative.

Second, I predict that new experimental techniques will continue to flower, and that whenever we acquire some new tool for looking at the natural world, we will see marvelous things. To look at the centenary issue of Physics Today, you will be amazed!