letters

Remembering Rabi: A challenge and a ghost story

Congratulations to PHYSICS TODAY for publishing the fascinating lecture by I. I. Rabi, "Stories from the Early Days of Quantum Mechanics" (August 2006, page 36). I was particularly interested in Rabi's statement, "During the first period of its existence, quantum mechanics didn't predict anything that wasn't also predicted before. . . . The results that came out of quantum mechanics had to a large degree been previously anticipated." This goes directly against the view, frequently expressed in later years, that quantum mechanics was accepted because all of its predictions were confirmed. Presumably that means predictions in advance: deducing results that were not known before quantum mechanics was proposed in 1925–26. (Physicists and other scientists sometimes use the word "predict" to mean "deduce" a known fact, so the phrase "in advance" is needed to exclude that situation.)

But perhaps Rabi was right. After all, quantum mechanics was accepted by 1928, so there wasn't much time to carry out and publish new experimental tests of its predictions. My impression from Rabi's lecture and other sources is that quantum mechanics was quickly accepted by physicists primarily because it allowed one to derive in a very direct way, from a small number of postulates, all the correct results of the old quantum theory. Getting both the discrete (negative energy) and continuous (positive energy) states of the hydrogen atom from the same equation was especially impressive. The old theory could yield those results, but sometimes only by using an inconsistent collection of ad hoc assumptions—for example, the anomalous Zeeman effect. In addition, quantum mechanics gave correct results for phenomena—notably the spectrum and ionization potential of neutral helium—that had completely stumped practitioners of the old quantum theory.

Quantum mechanics did of course produce many "predictions in advance." My question is, did their confirmation have any significant role in persuading physicists to accept the theory by 1928?

A possible candidate for a confirmed prediction is electron diffraction: The Davisson–Germer and G. P. Thomson experiments of 1927 are often cited as confirmations of Louis de Broglie's wave theory. But there is some doubt about whether those experiments revealed a completely new phenomenon, theoretically predicted in advance. In any case, quantum mechanics went far beyond de Broglie's theory in its range of applications and philosophical consequences. So I propose a challenge to readers of PHYSICS TODAY: Find evidence that the confirmation of *any* prediction in advance, other than electron diffraction, led *any* physicist to accept quantum mechanics before 1928.

Rabi also said in his lecture that John Van Vleck was "very unfortunate" in publishing a book on the old quantum theory just before it became obsolete. I don't think we should feel too sorry for Van Vleck. His expertise in the old quantum theory helped him become, very quickly, a first-rate practitioner and expositor of the new theory. His review, "The New Quantum Mechanics," published in *Chemical Reviews* in 1928, is an excellent resource for anyone who wants to know what achievements helped persuade scientists to accept quantum mechanics at that time. And he did, after all, eventually win the 1977 Nobel Prize for his research.

Stephen G. Brush
(p2s1859@gmail.com)
University of Maryland, College Park

I enjoyed reading I. I. Rabi's "Stories from the Early Days of Quantum Mechanics." Graduate students particularly need to read stories like these to help them over the bumps they invariably encounter in their careers. With respect to the "Pauli effect," I have a more recent story suggesting that the effect persisted even after his death! At a 1961 meeting of the American Physical Society at the New Yorker Hotel in New York City, Richard Feynman gave a talk to a packed conference hall on the quantization of the gravitational field. He started out in typical Feynman fashion by saying, or actually shouting, "Pretend Einstein never existed!" At this point, those of us in the hall heard a noise coming from the ceiling: A loudspeaker had come loose, dangled for a moment from attached wires, and then finally plunged to the floor. No one was injured, and amidst laughter after the shock wore off, Feynman continued. Victor Weisskopf, who had also been a student of Pauli's, was heard to remark, "That was Pauli's poltergeist." Feynman later elaborated on his talk to a huge audience at Columbia University, but as far as I know, no further Pauli poltergeist activity was reported.

Frank R. Tangherlini
(frtan96@sbcglobal.net)
San Diego, California

Coordination, research needed in weather science

At the onset of another hurricane season, Gavin Schmidt's Quick Study piece on "The Physics of Climate Modeling" (PHYSICS TODAY, January 2007, page 72) could not be more timely nor on a topic of greater importance. It follows one by Kerry Emanuel in the August 2006 issue (page 74) on thermal aspects of greenhouse gases contributing to hurricane genesis. And in the November 2006 item "Science Board Recommends Major Hurricane Research Program" (page 30), Jim Dawson directed attention both to the devastation wreaked by Hurricane Katrina and to a National Science Board panel convened to investigate the root causes of severe, damaging storms and ways to ameliorate their effects. We're among the concerned scientists and engineers who have written letters in support of the NSB effort, and we now provide additional information on the topic.

Letters and opinions are encouraged and should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842 or by e-mail to ptletters@aip.org (using your surname as "Subject"). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit submissions.

First, we underscore the broader need for research funding by pointing out that the topic of weather damage encompasses more than hurricanes developing from severe storms over water. Dawson's November article stated, "Politicians from the Dakotas and Montana 'don't think [research on hurricanes] is their problem.'" However, tornadoes spawned by severe storms over land are very much an increasing threat to people, infrastructure, and property in the US interior. Tolls associated with these devastating killers are staggering. On average, 800 tornadoes occur nationwide each year. The Environmental Protection Agency states that tornadoes annually cause approximately $1.1 billion in damages and around 80 fatalities. On 3 May 2003, for example, a series of tornadoes ripped through Oklahoma City and its environs, leaving 48 people dead and causing more than $1 billion in damage. The hurricane insurance losses for 2005 were $57 billion, the highest ever before Hurricane Katrina, whose costs are still being counted. And on 5 May 2007, a single tornado with winds up to 205 miles per hour struck and essentially destroyed the town of Greensburg, Kansas. Thus, whether over land or sea, there are more than enough concerns about personnel, infrastructure, and finances to warrant investing in research on severe storms.

Second, now appears to be an optimum time for bringing together the previously estranged communities of weather modification practitioners, who are mostly supported by insurance industries, and research academics, who have very limited funds. A considerable amount of data on practical weather modifications has accumulated, and significant advances have occurred in fundamental model descriptions of severe-weather-based instabilities; for example, two of us (Armstrong and Glenn) have reexamined the role of electrification forces in contributing to tornado formation.[1] With coordinated efforts, a new, stronger community can be formed to advance the art and science of weather modification.

In another case, Jürgen Michele, Vladimir Pudov, and one of us (Alamaro) have been discussing a concept inspired by a 1970s Soviet weather-modification program in the Baltics.[2] In that program, an array of jet engines was employed to form a vertical air flow that, it was hoped, would be sufficient to cause cloud formation. Even in a stable atmosphere, 9 out of 15 tests led to cloud formation. Alamaro and coworkers presented the hypothesis that the method may be used for such weather modification applications as frost prevention, fog dispersion, and, most ambitiously, hurricane modification. In the case of hurricane modification, a designed array of multiple jets would be used to create atmospheric perturbations that might turn a hurricane back to sea.

References

1. R. W. Armstrong, J. G. Glenn, *J. Weather Modif.* **38**, 77 (2006); available at http://alamaro.home.comcast.net/JWM_armstrong_glenn.pdf.
2. M. Alamaro, J. Michele, V. Pudov, *J. Weather Modif.* **38**, 82 (2006); available at http://alamaro.home.comcast.net/WMA_April_2006.pdf.

Ronald Armstrong
(rona@eng.umd.edu)
University of Maryland, College Park
J. Greg Glenn
(joseph.glenn@eglin.af.mil)
Eglin Air Force Base, Florida
Moshe Alamaro
(alamaro@mit.edu)
Massachusetts Institute of Technology
Cambridge

Stories and statistics of Bose

Kameshwar Wali's article on Satyendra Nath Bose (Physics Today, October 2006, page 46) prompts me to narrate a few incidents about the great physicist. My father, cardiologist Sunil Bose, was his contemporary at Presidency College in Kolkata, India (1909–11), and later his doctor and friend. My siblings and I were thus brought up on tales of his genius. Bose was omnivorous in his quest for knowledge, and even as a student of physics at Presidency College, he would often borrow and devour books on anatomy and physiology. Chemists would come to him to solve their problems and would leave wiser. Here is an example of his creativity: An "indelible" ink was used in the first Indian general election in 1952 to mark the fingers of voters. He playfully found a solution that could erase the ink mark.

It is fairly well known that Bose never bothered to submit a doctoral thesis. Of value to the physics community is the role he played as mentor to generations of students and researchers. I offer one example: In the early 1940s, his student Shyamadas Chatterjee had set up an experiment at the Bose Institute in Kolkata to study the newly reported fission of uranium when bombarded with neutrons. While setting up the experiment, Chatterjee found that distinct counts were recorded even without the neutron source. Puzzled, he reported the phenomenon to Bose, who at once came to the conclusion that it must be due to spontaneous fission. The half-life they calculated, which later proved to be correct, was way above that attributed to Edward Teller. As a result, by order of the institute's director, whose permission he had failed to obtain, Chatterjee had to withdraw the paper describing his findings. The phenomenon was discovered almost at the same time by Georgii Flerov and Konstantin Petrzhak in the Soviet Union. Chatterjee published his work later and was recognized by the Russian authors.

Chatterjee shared with me the story of a visit Paul Dirac made to Kolkata in the early 1950s to give a lecture at the Institute of Nuclear Physics. As Dirac spoke, Bose, sitting in the front row, appeared to doze off. Writing an equation on the blackboard, Dirac seemed to hesitate and looked toward the white-haired Bose for confirmation. Bose lumbered to his feet, scribbled the rest of the equation, and then resumed his earlier somnolent posture.

After the lecture, Dirac and his wife were ushered into the rear seats of a car, while Bose, Chatterjee, and one other person were about to occupy the front seats. Dirac demurred and requested that Bose join him in the back. Quick as a flash came the reply—"We follow Bose–Einstein statistics in front, you should follow Fermi–Dirac at the back!"

Wali mentions Bose's connection with the swadeshi movement and the names of Manabendranath Roy and Abani Mukherjee. Bose was also a close family friend of the nationalist leaders Sarat and Subhas Chandra Bose, who were students at Presidency College at almost the same time as S. N.

Dwarka N. Bose
(tutubose@yahoo.co.in)
University of Calcutta
Kolkata, India

In his excellent article "The Man Behind Bose Statistics," Kameshwar Wali mentions that Albert Einstein proposed to Bose that he work on two problems: "first, whether the new statistics implied a novel type of interaction between light quanta; and second, how the statistics of light quanta and transition probabilities would look in the new quantum mechanics."