letters

Tributes to Hans Bethe continue

The October 2005 special issue of PHYSICS TODAY describes the breadth of Hans Bethe's accomplishments and interests in different fields of physics. Here are two additional contributions of his that illustrate his ability to produce new advances in areas outside those for which he was most famous.

In 1929 Bethe employed group theory to examine how the crystalline field would split the energy levels of free ions and determined the symmetry required to fully quench the orbital moment.[1] This area became an active research field only after World War II, with the development of electron paramagnetic resonance and spin Hamiltonians.

Richard Garwin and Kurt Gottfried (PHYSICS TODAY, October 2005, page 52) mention that Bethe invented his hole coupler between two waveguides and developed his "exhaustive theory" of the coupler while at the MIT Radiation Laboratory. A second significant contribution to microwaves and electromagnetic theory by Bethe and Julian Schwinger employed Maxwell's equations in calculating the fractional frequency shift $\Delta f/f$ when a sample is inserted in a resonant cavity. The fractional frequency shift provides a direct connection to the tensor electric permittivity and the tensor magnetic permeability of the sample. Two reports exist about this work.[2,3] However, the derivation is given by Walter Hauser,[4] who terms the expression for the fractional frequency shift the Bethe–Schwinger cavity perturbation formula.

This fundamental expression, although known to some microwave experts, is not mentioned in the best-known electricity and magnetism texts. It is also not mentioned in the MIT Radiation Laboratory series that appeared shortly after World War II. John Slater's postwar text[5] mentions the 1943 MIT report[2] but doesn't give the Bethe–Schwinger formula. I was unaware of this expression until the early 1990s, even though I'd learned microwave techniques in the 1950s. Why wasn't this result published in an American physics journal? The report dates may provide a clue: Bethe was already at Los Alamos in early 1943.

References

1. H. A. Bethe, *Ann. Phys. (Leipzig)* **3**, 133 (1929).
2. J. Schwinger, MIT Radiation Laboratory rep. no. 43-34, MIT, Cambridge, MA (21 May 1943).
3. H. A. Bethe, J. Schwinger, National Defense Research Council rep. no. D1-117, Cornell U., Ithaca, NY (1943).
4. W. Hauser, *Introduction to the Principles of Electromagnetism*, Addison-Wesley, Reading, MA (1971), p. 511.
5. J. C. Slater, *Microwave Electronics*, Van Nostrand, New York (1950), p. 131.

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Kurt Gottfried wrote, "For almost seven decades, [Hans Bethe's] wife Rose was his constant companion and closest adviser" (PHYSICS TODAY, October 2005, page 36). Sam Schweber (page 38) explained that Bethe's 1928 thesis on electron diffraction in crystals built on previous work by Paul Ewald on the diffraction of x rays by crystals. The two statements are intimately connected.

In his 1981 "Reminiscences of the Early Days of Electron Diffraction," Bethe wrote the following:

> On the basis of my thesis, I was invited by P. P. Ewald to give a talk at a small conference on diffraction which he was arranging in Stuttgart in 1928. Apparently my talk pleased him, because a year later he asked me to become his assistant. I had a most enjoyable semester there, with a great deal of research, and close personal contact with Ewald and his family. Out of this I got a wife: Ewald's daughter, then 12 years old, was already very attractive, but I did not dream of marrying her. Eight years later, I met her again, and in 1939 we got married. So I owe a great deal to electron diffraction.[1]

Arnold Sommerfeld had proposed that Bethe make a detailed theory of electron diffraction in a crystal. He recommended as a model the theory by Ewald of the diffraction of x rays, written in 1917. Bethe found that electron diffraction was a great deal simpler. In the x-ray case one has to contend with a vector field. He retained only Ewald's fundamental idea, the expansion of a spherical wave—that is, the wave scattered by an atom—in terms of plane waves. Thence Bethe developed the theory of electron diffraction in first-order perturbation theory.

Reference

1. H. A. Bethe, in *Fifty Years of Electron Diffraction*, P. Goodman, ed., Reidel, Dordrecht, Netherlands (1981), p. 73.

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I very much enjoyed the special issue on Hans Bethe, one of the greatest physicists of our time. However, I was a little disappointed that save for a single sentence on page 36 almost no mention is made of Bethe the teacher. The American Association of Physics Teachers recognized him as a "teacher of teachers as well as students." I had the honor of presenting him with AAPT's 1993 Oersted Medal, which recognizes outstanding contributions to the teaching of physics. Bethe remarked to me that he cherished that medal as much as any he had received. I believe only Bethe and Richard Feynman have received both the Oersted Medal and the Nobel Prize in Physics. Bethe's address as part of the Oersted Award was published in 1993 in the *American Journal of Physics*, volume 61, page 971.

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The special issue celebrating the life of Hans Bethe admirably described his

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contributions to both physics and society. In physics it covered his work in astro-, nuclear, and condensed matter physics and in quantum electrodynamics. Perhaps not as well known were his extraordinary contributions to atomic physics. Our recent article discusses this aspect of his voluminous output.[1] It covers his seminal work on the stability of the negative hydrogen ion; details of his atomic-physics calculations regarding the Lamb shift; aspects of his important work in collision theory, especially his work in stopping power; several important aspects of atomic physics related to crystalline solids; and his books and review articles in the field.

Reference

1. M. Inokuti, B. Bederson, *Phys. Scr.* **73**, C98 (2006).

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I am a student from India now working on my PhD in chemistry at Emory University in Atlanta, Georgia. I am also deeply interested in the history of modern physics, and Hans Bethe was one of my favorite scientists. Saddened by his passing, I wrote a 12-page, spur-of-the-moment biography, mostly from my memory of the things I had read and heard about him. To me, Bethe will always be an exceptional example of the ideal scientist-citizen. He set the standards for the rest of us both in his scientific work and in his efforts towards arms control.

The influence of science and scientists really transcends time, nationalities, and generations. Every person on the street may not be familiar with Bethe and his work, but I am certain that he and others of his stature have, in many subtle ways, inspired young people like me to pursue careers in science and to be more conscientious citizens of the world. I believe that this often unseen, subtle, and deep influence of science and scientists fuels the engines of conscience and progress. Those who want reassurance about the enduring benefits of science as an instrument of rationality and social enlightenment need not look very far.

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Gottfried comments: I erred in not including an article on Hans Bethe's work in solid-state physics in the special issue. Physics Today published "A Conversation About Solid-State Physics" by Bethe and N. David Mermin in its June 2004 issue (page 53). And fortunately, an excellent article by Mermin and Neil W. Ashcroft was published recently: "Hans Bethe's Contributions to Solid-State Physics," in *Hans Bethe and His Physics* (World Scientific, 2006, p. 189).

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NASA's mission of space exploration: Some fine points

Roger Blandford's Reference Frame titled "Exploring the Universe" (Physics Today, April 2005, page 10) summarizes many of his concerns regarding NASA's plans for astronomy and space science in the context of President Bush's vision for space exploration. As Blandford notes, given the long list of ambitious space telescopes in NASA's plans, clearly priorities need to be set, and some astronomers worry that "programs with a connection to life will be favored over fundamental investigations in the inanimate, physical sciences." The president's vision explicitly calls for NASA to "conduct advanced telescope searches for Earth-like planets and habitable environments around other stars"[1] and categorizes future NASA missions such as the *Space Interferometry Mission* and the *Terrestrial Planet Finder* as high-priority and life-oriented. Blandford states, "The discovery of extrasolar planets, 150 and counting, demonstrates that our solar system is unrepresentative with immediate consequences for the quest for extraterrestrial life." This statement would seem to weaken the case for placing high priority on *SIM* and the *TPF*. However, Blandford draws the incorrect conclusion that the more than 160 current extrasolar planet candidates[2] imply that our solar system is unrepresentative and hence that the search for habitable planets may be extraordinarily difficult.

Finding an exact analogue of our planetary system is highly unlikely, given the chaotic processes involved in planet formation, yet scientists have no reason to believe that planetary systems similar to our own are not commonplace. The 160 known extrasolar planetary systems were nearly all discovered by Doppler spectroscopy and photometric transits, methods that strongly