1941, I did refer to a "march of events" (my words) that he apparently perceived as leading toward nuclear weaponry. I don't see where I referred in this article to "Heisenberg's 'bomb work.' "

I also tried to show how, in hindsight, Heisenberg, as well as many other prominent Germans, had been used by the Third Reich for its own purposes. Obtaining such lessons is among the tasks and benefits of history. I explored this topic in my biography.[1] With encouragement from Max Planck, Heisenberg came to believe, long before the outbreak of war, that he personally must survive in Germany so that his students and decent German science could survive.

The war began nearly 7 years into the 12-year reign of the Third Reich. We cannot fully understand behavior during the war without first examining attitudes and responses established during the pre-war years. Some authors have reached what I find to be untenable conclusions because they neglected to consider the preconditions. Gottstein disagrees with my understanding of Heisenberg's rationale, but we would have to work through the earlier years to determine exactly where we disagree.

My suggestion that Heisenberg might have consulted with Planck and Max von Laue also refers to the earlier years, specifically 1933 through 1936, when the three men frequently discussed how best to respond to the Nazi assault on physics and on academe in general.

I agree with many of Gottstein's other comments, in particular, that Heisenberg's invited travels "brought him and modern physics a level of esteem" in Germany, which is why he accepted the invitations.

Lipkin's report of Bohr's reaction to the visit and to Heisenberg's subsequent remarks on the lack of progress in fission research may find support in Bohr's unpublished letter to Heisenberg regarding Robert Jungk's book.[2] However, as Gerald Holton reported, the Bohr family has sealed this letter until 2012.

References

1. D. C. Cassidy, *Uncertainty: the Life and Science of Werner Heisenberg*, Freeman, New York (1992).
2. R. Jungk, *Brighter than a Thousand Suns: A Personal History of the Atomic Scientists*, Harcourt, Brace & Co., New York (1958).

David C. Cassidy
(chmdcc@hofstra.edu)
Hofstra University
Hempstead, New York

Haigerloch Cave Survived the War

The figure caption "Dismantling the Last German Atomic Pile" (Physics Today, July 2000, page 35), contains two incorrect statements.

The dismantling of the pile occurred not after the war, but in April 1945, a few weeks before the war ended in Europe.

The cave was not blown up by the American soldiers. The laboratory was dismantled and the utilities disconnected, but the cave as such was not destroyed. According to the recollections of older residents in Haigerloch, the destruction was avoided by a local priest, who persuaded the Americans to refrain from the destruction because an explosion would have also destroyed a medieval church and castle on the cliff above the cave. Incidentally, Heisenberg occasionally played Bach on the organ of that church.

Today, there is a small museum in the cave, with original and reconstructed artifacts. Visitors are most impressed by how unbelievably small and primitive the historic laboratory was, compared to the gigantic and elaborate technology of the Manhattan Project. It looks more like a Tinkertoy™ arrangement than something on the forefront of technology at the time; however, if completed, the Haigerloch laboratory would have led to huge sources of energy and the power for enormous devastation!

Otto G. Folberth
Böblingen, Germany

[Editor's note: We contacted Michael Thorwart of the Atomkeller Museum at Haigerloch. He and Egidius Fechter, director of the museum, provided the following detailed information on the dismantling of the German nuclear lab and the fate of the cave that housed it.]

BOTH PHOTOS © 2001 E. FECHTER

Figure 1 (above). Reconstructed model reactor in the original hole, Atomkeller Museum, Haigerloch, Germany.
Figure 2 (left). Damaged outer reactor vessel, on display at the museum.

Thorwart and Fechter comment: The French army arrived in Haigerloch on Sunday, 22 April 1945, but took no notice of the underground nuclear lab. The war in Germany officially ended on 8 May 1945.

American–British ALSOS forces arrived on Monday, 23 April 1945, with the lab as their target, and soon dismantled it. According to our archive, the photograph in Physics Today showing the dismantling was taken by Samuel Goudsmith, the scientific head of ALSOS, on 24 April 1945. So, this was very near—but before—the official end of the war.

German scientists had removed the uranium cubes and the heavy water from the lab and hidden them before ALSOS arrived. They left only the inner and outer vessels and the graphite block that separated them.

Colonel Boris Pash of ALSOS initially planned to destroy the entire cave. However, local priest Monsignore Marquard Gulde convinced him that the beautiful baroque church on top of the cave would also be destroyed. After ALSOS forces had found and confiscated the heavy water, the uranium, and the inner vessel, Pash agreed to spare the church, possibly because he realized that the lab was too small for any future German nuclear experiments. He ordered a very limited explosion that destroyed the remaining outer vessel within the cave.

The Atomkeller Museum is underground and the original structure is completely preserved—even the hole for the reactor vessel, which now contains a model of the original reactor, as shown in figure 1. Aside from the damaged outer vessel, shown in figure 2 as it appears today in the museum, no evidence of the explosion exists. The museum is open to the public. See http://www.haigerloch.de/keller/EKELLER.htm.

Michael Thorwart
Egidius Fechter
Atomkeller Museum
Haigerloch, Germany

Born Coined the Term

In the article by Gerald Holton (Physics Today, July 2000), the photograph caption on page 39, stating that Werner Heisenberg named the new physics "quantum mechanics," is misleading.

The expression "quantum mechanics" was first used in the scientific literature by Max Born in a 1924 article in which he discussed "the formal passage from classical mechanics to a quantum mechanics."[1]

When Heisenberg wrote his famous paper[2] that laid the foundations of the new theory, he used Born's expression; the term was common in articles by Born, Pascual Jordan, Heisenberg, Wolfgang Pauli, and Paul Dirac that appeared immediately afterward. In particular, Born and Jordan's paper that introduces the subject of matrix mechanics bears the title "On Quantum Mechanics."[3]

These statements are based on Bartel Leendert van der Waerden's well-known book on the history of quantum mechanics,[4] which includes English translation of the principal works.

References

1. M. Born, *Zeitschrift für Phys.* **26**, 379 (1924).
2. W. Heisenberg, *Zeitschrift für Phys.* **33**, 879 (1925).
3. M. Born, P. Jordan, *Zeitschrift für Phys.* **34**, 858 (1925).
4. B. L. van der Waerden, *Sources of Quantum Mechanics*, Dover Publications, New York (1967).

Carlos D. Galles
(cgalles@satlink.com)
National University of Rosario
Argentina

Education Must Capture Student Enthusiasm

The success of the play *Copenhagen* demonstrates once again the public's potential enthusiasm for physics and related societal topics.

Now cut to physics education, where introductory courses dwell on classical mechanics and electromagnetism with at most a superficial introduction to special relativity and "old" (pre-1925) quantum physics. We seldom hint that Newton's laws are only low-energy approximations to the quantum-relativistic principles that seem to describe the universe, that Newtonian mechanics is not valid for most phenomena, and that an enormous conceptual gulf exists between a Newtonian clockwork mechanism and contemporary physics.

Do physics students experience the depth and excitement elicited by *Copenhagen*? I think not. Do they sense the wonder of the uncertainty principle, or do they, at best, merely run through yet another formulaic calculation involving symbols called delta-x and delta-p? Do they ever hear anything about, say, quantum entanglement, a phenomenon that has perplexed physicists since the 1930s, that is comparable in significance to quantum uncertainty, and about which significant new results have appeared regularly since the 1960s? Even in courses for nonscientists, in which there is no constraint to cover the encyclopedic minutia of Newtonian mechanics, we fill our students' brains with watered-down versions of the "real" physics courses that are based on the manipulation of classical formulas.

We are living in what should be the golden age of physics education. Physics has never been so exciting. We've been given the Big Bang, dark matter, quantum entanglement, and much more. A smash Broadway hit is even based on the subtleties of physics, and of its social implications. We are not required to throw this excitement away when we enter the classroom. Small enrollments, student antipathy to anything titled "physics," and lukewarm public support need not be our fate. By replacing formulaic manipulation with conceptual understanding, and above all by focusing on modern concepts and societal connections, teachers can capture the latent enthusiasm for ideas that is so evident in the success of *Copenhagen*.

Art Hobson
(ahobson@mail.uark.edu)
University of Arkansas
Fayetteville

Pantazis Mouroulis (Physics Today, November 2000, page 78) writes that teaching "the Big Bang to college sophomores is a bad idea." He goes on to say "Real science courses should be taught only when students have the background to appreciate