

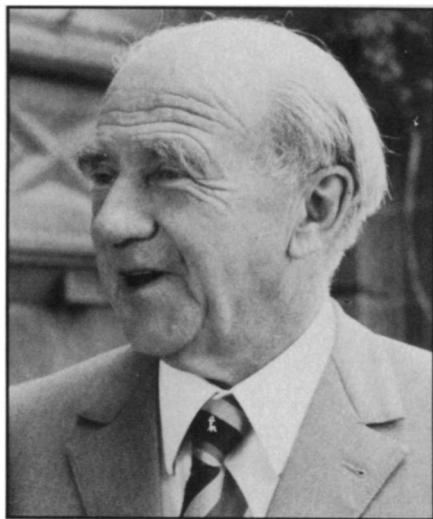
## An appreciation of Werner Heisenberg and some talk about how physics was in the good old days

The day after Werner Heisenberg died, three men who had known him, I. I. Rabi, Samuel A. Goudsmit and George E. Uhlenbeck, were gathered for a press conference at a meeting of the American Physical Society. The occasion was one for reminiscence: The press conference was intended to deal with the half-century anniversary of Goudsmit and Uhlenbeck's discovery of electron spin, but before they got down to that topic, the participants talked of Heisenberg and how physics was in the days when they and Heisenberg, and also P. A. M. Dirac and Louis de Broglie and other famous physicists, were young men. ("But not Schrödinger," Goudsmit reminds us. Erwin Schrödinger, one of the founders of quantum theory, was a generation older than this group.)

Some general remarks of Goudsmit's set the stage: "Physics in those days was a calling. Today it's a profession." One didn't become a physicist for money or fame. "Everybody in my family was in business," Goudsmit says, and they thought it decidedly odd of him that he chose to become a physicist.

Physics was also a small world in those days. Goudsmit remarks that students today are amazed to learn that he knew Einstein and Bohr and other legendary figures, but then it was a little group who all knew each other and were continually visiting each other. (It had a small group's spites and sibling rivalries, too, as will come out later.)

Heisenberg visited Leyden (where Goudsmit was studying) several times. "He was an open, fine young person in whom you had absolute complete confidence," Goudsmit recalls. "He was brilliant but had a high opinion of himself." He never consulted books but worked everything out for himself. He derived the theory of quantum mechanics in the form called matrix mechanics, inventing new rules of mathematics without realizing they already existed. Paul Ehrenfest (Goudsmit and Uhlenbeck's teacher at Leyden) said that Heisenberg was just like Newton, inventing new math as he went along, but when Heisenberg got back to Göttingen with his formulations, people laughed. They said he must have been



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*A few years back Isaac Asimov prepared a list based entirely on his own opinions of the 72 "greatest scientists of history." Only four scientists on the list were still living. The first three were Louis V. de Broglie, Francis H.C. Crick and Linus Pauling. The fourth was Werner Heisenberg, here depicted in 1973 as he visited the Smithsonian Institution's celebration of Copernicus's quincentenary.*

asleep during David Hilbert's lectures. The math in question had been around for a hundred years.

The mathematical preparation of physicists had some surprising holes in it in those days. "When I was a young man," says Uhlenbeck, "I thought all a physicist needed in math was multiplication and addition. Now I have changed my mind." It also came out in the discussion that in those days Dirac, who is one of the great men of mathematical physics, didn't know spherical harmonics and didn't use them, although they would have greatly helped in his formulation of quantum electrodynamics.

The physics of physicists had some odd lapses, too. Uhlenbeck relates that Heisenberg flunked an exam on the principle of the telescope. To be fair, that is something of a side issue in physical theory, and it's a tricky question when sprung unawares. It was thrown into Heisenberg's oral examination by Wilhelm Wien, who did it for spite. Heisenberg was a student of Schrödinger, and Wien and Schrödinger were on the outs, so Wien did everything he could to embarrass Schrödinger's students. The funny thing is that later on Heisenberg used the principle of the microscope, essentially the same as that of the telescope, to work out his famous uncertainty principle, one of the philosophical foundations of quantum physics.

Goudsmit had a somewhat analogous experience—though not out of anyone's spite. He failed an exam in analytical

mechanics (one of the traditionally important branches of classical physical theory), and so when he received his license to teach in high schools in the Netherlands, it specifically excepted mechanics from the subjects on which he was permitted to lecture. Ironically, when he later joined the University of Michigan, mechanics was one of the first subjects he taught.

"I was in [Heisenberg's] institute in Leipzig a semester," says Rabi. "As a result of that he got me my job at Columbia in 1929. I wouldn't have had a job in 1930 or 1932. And so I have a feeling of gratitude.

"[Heisenberg was] one of the very great physicists, though I don't think he was a very great man in the sense that Bohr was. He had fantastic insight and taste and was dedicated to a certain philosophy in later years. . . . Basically, physics was one world. He was bored with all these new particles."

Depression or not, those years were a difficult time for young physicists to find jobs. In the Netherlands the best a new Ph.D. could hope for was a teaching post in a provincial high school. In scornful reference to the dismal prospects, Ehrenfest always used to use the name of a small town in southern Holland as an example of rustic exile. Then, says Goudsmit, he happened to visit the place and liked it. So thereafter he used another name.

But when Goudsmit and Uhlenbeck came to look for jobs as physicists, they had already published their work that explained some then mysterious behavior of atoms by the postulate of spinning electrons. This so impressed the University of Michigan that it invited them to join its faculty, and both did.

"Heisenberg visited me in Ann Arbor before the war," Goudsmit recalls. "Everybody tried to convince him to stay, but he loved Germany so much and was convinced it would change and that he could play a role. 'Germany needs me.'"

Because Heisenberg spent the war years in Germany, many people have thought he was a Nazi. "He was not a Nazi sympathizer," Goudsmit insists. (Goudsmit lost both his parents in the massacre of the Dutch Jews, and has no reason to be protective of people who merit that accusation.) Relativity and quantum mechanics had been forbidden by the Nazis as "Jewish physics," and the professors were mostly selected by party officials. Heisenberg used a family connection with Heinrich Himmler to get permission to teach relativity and so kept a stream of modern physics alive in Germany during the evil years, but at the cost of strictly separating scientific from political activity. "He saved physics; he did not save physicists," Goudsmit concludes.

—Dietrick E. Thomsen