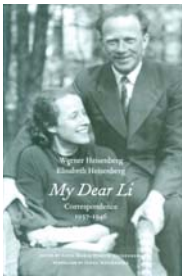
BOOKS

My Dear Li

Correspondence 1937–1946

Werner Heisenberg and Elisabeth Heisenberg
Edited by Anna Maria Hirsch-Heisenberg (translated by Irene Heisenberg)

Yale U. Press, 2016. $40.00 (328 pp.). ISBN 978-0-300-19693-1



In January 1937, 35-year-old Werner Heisenberg met 22-year-old Elisabeth Schumacher at a musical event in Leipzig. Two weeks after they had met they were engaged, and four months later they were married. A recent collection of their letters, *My Dear Li: Correspondence 1937–1946*, captures the Heisenbergs' relationship during the first decade of their marriage. It also sheds light on the fraught question of Werner Heisenberg's work for the Nazi regime during World War II.

The letters between the Heisenbergs fall into three sets. The first contains the letters they exchanged before they were married; the second contains the ones written when Werner was visiting the UK and the US in summer 1939; the third, the bulk of the book, is the letters they exchanged after war broke out in Europe in September 1939.

The earliest letters highlight the deep love that the couple already had for one another during their engagement. After their marriage they grew together, making music together, sharing poetry, nurturing their communion with nature, being good Lutherans, and especially bringing children into the world—six of them by 1944.

The second set of letters, from the summer of 1939, show us a Heisenberg fully cognizant of what had happened in Germany since Hitler and national socialism took power in 1933. A Heisenberg who is called a "white Jew" for teaching relativity and who is denied Arnold Sommerfeld's chair at the University of Munich after Nazi supporters target him with a smear campaign. A Heisenberg who believes that war will break out that fall.

They also show us a Heisenberg who believes that the fear of Bolshevism makes understandable and to some extent justifies what is happening in Nazi Germany. He writes to Elisabeth of the offers he received to stay in the US—at Columbia University and the University of Chicago—and admits that although the positions would be good for his work, "we just are not at home here. The children would speak English and grow up in an atmosphere that is foreign to us. That would not be nice at all, and so we are just staying put."

After the outbreak of war, Werner's professorial duties in Leipzig, his position running the Kaiser Wilhelm Institute for Physics, and his decision to work on the German atomic bomb project made for ever lengthier separations. The wartime letters testify to Elisabeth's heroic efforts to make the children's lives bearable and as safe as possible under increasing shortages of food and coal, ever more frequent air raids, and news of the death in combat of close family members and friends. They also tell of Werner's growing difficulties in carrying out his professional duties; there were daily nighttime and daytime aerial bombardments in Leipzig and Berlin, increasing difficulties with his frequent travels, and growing concerns about the welfare and safety of his family. Those stresses contributed to frequent, incapacitating bouts of hay fever.

The letters also make evident that during the war, Werner never told Elisabeth he was trying to make atomic bombs.

Historians have differed, often passionately, on how harshly to judge the great physicist for his wartime decisions. I came away from reading *My Dear Li* with the belief that the critical views of Heisenberg expressed by historians such as Jeremy Bernstein are closer to the mark than the more generous interpretation offered by biographer David Cassidy. What seems clear from these letters is that whatever reservations he may have had, Heisenberg identified with Nazi Germany. He was disappointed that Great Britain did not respond to German peace overtures after the defeat of Poland. He was pleased with the defeat of France. He willingly took on the role of Nazi Germany's cultural ambassador in Hungary, Poland, and Denmark.

His letter to Elisabeth after his famous meeting with Niels Bohr in September 1941 speaks of accepting "his assigned part . . . to defend our system" during a political discussion at the Bohr house. It also reveals his incomprehension of why the members of Bohr's Institute for Theoretical Physics were unwilling to attend his talk at the German Scientific Institute, since "the Danes are living totally unrestricted and are doing so well"; he blames their stand on the "hatred and fear that had been galvanized here."

There is much else in the third set of letters, including Werner's account of the harrowing last days of the war, his capture, and his internment at Farm Hall; the inclusion of the diary he kept there; and an account of the reasons he resettled in Göttingen after coming back to a partitioned, defeated Germany. I shall only comment on the content of the letter he wrote from Farm Hall to Elisabeth on 9 January 1946, suggesting how she should respond if asked whether he had been connected with the "atomic bomb."

Werner sent Elisabeth a copy of a section of a letter that his fellow Farm Hall resident Carl von Weizsäcker had written to his wife, a letter that Werner claimed "describes this problem just right. I know many of the British and American colleagues who worked on it, some of them are my pupils, and they have my sympathy, because their name is now tied to this *atrocity*" (my emphasis). The section of von Weizsäcker's letter contained the famous statement: "We were spared the difficult moral decision whether we should build an atomic bomb. The technical and organizational work means available to us in Germany would not have permitted at all the effort America had put forth."

Heisenberg's statement implies that he believed that his "British and American colleagues" at Los Alamos did not

address the difficult moral question of whether they should build an atomic bomb. The fact is, they did. But in any case, *My Dear Li* shows that Heisenberg avoided addressing his own moral dilemma.

Writing to Otto Hahn in 1948, Lise Meitner forcefully stated, "It is very clear to me today that I committed a great moral wrong by not leaving in 1933, since in the last analysis by staying I supported Hitlerism." I believe the same was true of Heisenberg, who not only remained but worked with the Nazi regime. Heisenberg believed strongly in the purity of the scientific enterprise, the excellence of German institutions, and the importance of their preservation. Those convictions allowed him to identify with Nazi Germany and justify to himself his collaboration.

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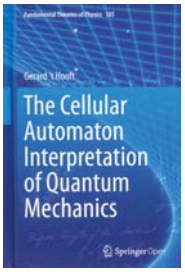
[Editors' note: With sadness, we inform our readers that Silvan Schweber died on 14 May 2017.]

The Cellular Automaton Interpretation of Quantum Mechanics



Gerard 't Hooft

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When I was a particle-physics graduate student back in the 1980s, Gerard 't Hooft was a hero to me and my fellow students. A recognized grand master of quantum field theory, he had established in his PhD thesis gauge theories as a usable tool—a tour de force later rewarded with a Nobel Prize—and then went on to contribute a long series of startling, deep, and diverse insights. Yet when we finally heard 't Hooft deliver a lecture to our department, we were baffled by his arcane choice of subject: quantum mechanics inside a black hole. It seemed totally disconnected from what everybody else was working on. Thirty years later everybody knows about the black hole information paradox, which has led to hundreds of papers and some profound insights and is even the topic of popular science books.

With *The Cellular Automaton Interpretation of Quantum Mechanics*, 't Hooft has managed to surprise me once again by proposing a new way of looking at that branch of physics. His stated goal is to show that Albert Einstein was right to think that there is no fundamental randomness in nature—a conclusion contrary to the belief of the founding fathers of quantum mechanics and of most contemporary working physicists, and contrary to what is taught in any quantum mechanics class.

Of course, the predictions of quantum mechanics have been experimentally verified beyond any reasonable doubt, and 't Hooft is well aware of the difficulties encountered by any attempt to derive those predictions from an underlying deterministic theory. In fact, he takes the view that any modification of the basic equation of quantum mechanics—the Schrödinger equation—should be rejected. Yet he also proposes that the apparent randomness of the quantum world can be explained deterministically.

In his new book, 't Hooft manages to reconcile the apparent contradiction by exploiting a simple yet deep observation: If one could identify at all times the basis in which the evolving state of the system is not a superposition, then it would be possible to extract fully classical predictions. In particular, it would be possible to avoid the collapse of the wavefunction. According to 't Hooft, an "ontological" preferred basis can exist in which the state of the universe evolves deterministically. The reason why we perceive randomness in the universe is that we are using the "wrong" basis.

That interpretation, argues 't Hooft, avoids the pitfalls of previous attempts to derive quantum mechanics from underlying deterministic "hidden variables" because it abandons freedom of choice. For example, in the famous Einstein-Podolsky-Rosen paradox, the set of possible outcomes of a measurement depends on the observable that is being measured. The paradox arises because a deterministic explanation of all possible measurement outcomes for a given system would require the system to have mutually incompatible properties before the measurement is performed. In 't Hooft's "superdeterministic" interpretation, universal conservation laws require that out of all possible measurements, only one can actually happen. The paradox therefore disappears.

The Cellular Automaton Interpretation of Quantum Mechanics is divided into two parts. The first contains few equations and only some simple calculations—examples worked out at critical junctures to make arguments concrete and understandable. The second part is a collection of computations that demonstrate explicitly how 't Hooft's idea may be realized in practice. That is where cellular automata come in: 't Hooft's preferred basis, like a cellular automaton, evolves in discrete time steps with an unobservably small scale (perhaps set by the Planck length).

At the beginning of the book, I couldn't help but experience disbelief. Yet as I delved into it, I started wondering, "What if 't Hooft is right after all?" He is well aware that he is treading a minefield. Somehow, he manages to levitate a few inches above ground, supported by a combination of practical computations and candid admissions of what he does and does not understand.

So will 't Hooft once again manage to pull off a magic trick, as he did in our department 30 years ago? Will everybody in 20, 30, or 50 years study quantum mechanics based on the 't Hooft interpretation? That is unlikely, yet it is hard to rule out the possibility. Certainly, if even a small fraction of the ideas proposed in the book turn out to be correct, then this most recent opus will dwarf all other contributions 't Hooft has given to science. For the time being, the best we can do is enjoy this beautifully written, entertaining, and provocative book and wonder whether we are prepared to change our mind about a basic and firmly held belief: The laws of Nature are fundamentally random.

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