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David C. Cassidy, *Beyond Uncertainty: Heisenberg, Quantum Physics, and the Bomb*. New York: Bellevue Literary Press, 2009, 456 pages. $27.00 (cloth).

In 1991 David Cassidy, Professor of Natural Sciences at Hofstra University and a highly regarded historian of physics, published a 669-page biography of Werner Heisenberg called *Uncertainty: The Life and Science of Werner Heisenberg*. Starting in the heady days during which quantum theory was born, Cassidy then took us through those wonderful years when the microscopic world revealed itself through the amazingly successful applications of quantum mechanics. He then followed Heisenberg and his many colleagues through their tortuous paths during the Nazi regime. It is really a masterful work. Cassidy has stated that he devoted more than six years to the research necessary to produce this book, and several more years in actually writing it. His effort shows. One can gain a pretty full picture of Heisenberg and of German and Western European physics during that amazing time by reading this single volume. And yet Cassidy now has produced a new volume, covering the same period, closely following the time line of *Uncertainty*. So why this new work?

The world has changed enormously since 1991, and these changes have had significant impact on our view of German bomb research and of Heisenberg's role in its pursuit. As Cassidy explains, the Cold War had ended, many new documents from German and Russian sources have come to light, nuclear proliferation has become even more threatening. Regarding Heisenberg himself, private family letters, not to mention Niels Bohr's drafts of letters to Heisenberg (never sent) about their famous meeting in Copenhagen in September 1941 have surfaced. Most dramatically, the play *Copenhagen* by Michael Frayn appeared and stimulated new interest in the entire question of German bomb research. It renewed the controversy, suggested in the play, that perhaps Heisenberg and his scientific colleagues had moral qualms that at the very least inhibited their enthusiasm in pursuing bomb research, and at the other extreme actually led to covert sabotage. Most importantly, the Farm Hall transcripts of secretly-recorded conversations of ten sequestered German scientists, including Heisenberg, who were captured by the Americans in the last days of the war, were published. They revealed the state of knowledge in Germany regarding both controlled fission (reactors), and uncontrolled fission (nuclear explosions) as of early 1945. The recordings revealed that they were far behind the United States and Britain, having not yet even constructed a reactor gone critical. They only had managed to produce a very primitive one with only a few tens of percent neutron enhancement. As a consequence of all this, a new look at Heisenberg would certainly seem appropriate, thus this new book.

Beyond Uncertainty has a subtly different emphasis than *Uncertainty*. The first six chapters, hardly changed, covered the period up to about 1920. Chapter 7 is quite different. The original contained a detailed discussion of the problems confronting physicists because of the complexities of atomic spectra in the presence of magnetic and electric fields. In *Beyond Uncertainty* the discussion becomes more general, relegating the challenging details to references. It becomes more personal. It contains a discussion of Heisenberg's earliest interactions and friendly confrontations with Niels Bohr, the then-acknowledged leader of theoretical physics in Europe, and of a generation older than Heisenberg. It also admirably summarizes the earliest days of quantum mechanics, as it struggles to move out of the classical world, driven by the increasingly precise spectroscopic data then appearing.

With all that has happened in the world since 1991 I believe that Cassidy decided to allow himself the luxury, not generally exercised by biographers, of actually expressing personal opinions (though of low key) on various aspects of Heisenberg's behavior and character. This is what makes the book eminently worth reading, even if you had read the earlier volume. Especially in its second half is a thoughtful presentation, with judgments, of that dreadful period of our history. It was a time when events occurred that are almost unimaginable even in hindsight. That German society, blessed with a cultural heritage that included science, philosophy, music, and literature unsurpassed in the world should have ended up with a brutal domestic dictatorship and with even more brutal military conquests, and death camps, remains an enigma not fully understood to this day. That a basically decent, highly cultured individual such as Werner Heisenberg should eventually find himself a perhaps reluctant participant in this

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tragedy is a matter that simply cries out for explanation. Cassidy has, I believe, helped to unravel this mystery, in a fair and balanced manner. It remains a cautionary tale for all of us – at what point does one draw a line in the sand?

A further important distinction between *Uncertainty* and *Beyond Uncertainty* concerns their intended audiences. The first is primarily accessible to a scientifically educated reader, although by skipping various technical parts it is eminently readable to the general public. (It does contain many equations which would be unintelligible to a nonscientist.) The second seems to be specifically aimed at the educated general public. It contains no equations; important concepts are described exclusively in words. While of course one loses something in discussing physics without equations, the gain is in narrative continuity – the new book is so readable that it is really hard to put down. Heisenberg; Nazi Germany; World War II; atomic bombs; quantum mechanics: what a combination! Here one is dealing with the very essence of twentieth-century history, at least a crucial part of it.

Cassidy confronts a fundamental question concerning the cultured and civilized German people – not the virulent anti-Semitic, angry Nazis and their sympathizers. Why did they go along with the Nazi madness? In particular, for Heisenberg himself, why did he choose to stay in Germany when it had already become clear what sort of regime Hitler was creating? As Hitler's Germany grew ever more evil, as it became clearer with time that Nazi excesses were not going mellow, but rather would grow even more extreme, why did Heisenberg not say: enough! Why didn't he leave Germany when he had many opportunities to do so? Cassidy carefully describes the private and public lives of Heisenberg. Born into an academically powerful family, with deep roots in German culture, Heisenberg was an unremitted German patriot, so deeply committed to the preservation of all that, supposedly, was good in the German character that he simply could not leave Germany, which, he believed, needed him more than ever. He never, in his entire lifetime, expressed regret over his choices.

However, before passing judgment, how many of us, under similar circumstances, would choose to leave our beloved countries?

As Cassidy makes clear, Heisenberg never compromised his physics to assuage Nazi ideology. The most "Nazified" physicists, such as Johannes Stark and Philipp Lenard, were proponents of "German physics" as opposed to "Jewish physics." The former, they claimed, was rooted in reality, placing experimental physics at a higher level than the abstractness of theoretical physics. The most obvious examples were relativity and quantum theory. But because of Heisenberg's need to be acceptable to the Nazi regime (he was never completed trusted) he was willing to espouse modern physics but at the same time agree not to reference Jewish physicists, such as Albert Einstein, who were so central to its creation. A perfect example of a slippery slope!

Heisenberg's defenders point to examples of his efforts to save individual Jewish scientists. Cassidy describes a number of such cases, although he calls them too little and too late. He particularly notes his inaction in a singularly tragic example, Heisenberg's failure to act on behalf of Samual Goudsmit's Jewish parents, who were trapped in Leyden, The Netherlands. They were subsequently killed in a concentration camp. With regard to the so-called moral positions that motivated Heisenberg and his German colleagues in their failure to produce atomic weapons (expressed mainly by themselves), Cassidy – hopefully for the last time – clearly debunks the claim that there were any.

The Heisenberg story – an iconic illustration of good and evil that never ceases to fascinate – is brilliantly retold in *Beyond Uncertainty*.

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