Die Quantentheorie
Ihr Ursprung und ihre Entwicklung

Von

Fritz Reiche

Mit 15 Textfiguren

Berlin
Verlag von Julius Springer
1921

The Quantum Theory

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With Fifteen Diagrams

Second Edition

METHUEN & CO. LTD.
36 ESSEX STREET W.C.
LONDON
Fritz Reiche was one of the very few research pupils of Max Planck ... He was a tiny delicate Jew who combined the typical humor of the Berliner with a deep melancholy and pessimism. ... I learned from him a great deal about radiation and quantum theory which he had studied at the source, in personal contact with Planck.

—Max Born

Fritz Reiche (1883–1969)

• Ph.D. with Planck, 1907
• 1908–11: in Breslau, learning experimental physics with Otto Lummer
• 1913: Instructor (Privatdozent) at the University of Berlin
• 1915–18: assistant to Planck
• 1919–1920: advisor to Fritz Haber’s Physical Chemistry Institute in Berlin; “little oracle”
• 1921–1933: Professor in Breslau
• 1921: publication of Die Quantentheorie

From late teens through mid 1920s, Reiche published a series of influential papers on quantum theory, on such topics as
• dispersion
• spectrum of helium
• rotational specific heat of hydrogen
In 1913, Arnold Berliner persuaded Ferdinand Springer to establish a new journal, *Die Naturwissenschaften*, which like *Nature in Britain* and *Science* in the United States, would report on new developments in all of the natural sciences to all scientists.

The rapidly progressing specialization in all branches of research in the natural sciences [Naturforschung] makes it difficult for the individual to become informed about even neighboring domains. It is almost impossible for him to become acquainted with more distant ones.

"Die Naturwissenschaften" is determined to fill this gap.

In June 1913, Reiche published a nine page, two part article on quantum theory, intended to summarize the 1911 Solvay conference. It was not the first article on quantum theory to appear in *Die Naturwissenschaften*. But it was by far the most comprehensive. Reiche began:

**Greek thinkers were the first to state clearly that all matter consists of small, indivisible particles, atoms.**

He discussed 19th century kinetic theory, Brownian motion, electron theory, and black-body radiation; and went on from there to give a thorough description of the experimental evidence for and theoretical scope of quantum theory in 1913, in clear, striking, non-technical language.

Reiche concluded by quoting Marcel Brillouin at the first Solvay Conference:

**It has become necessary to introduce a discontinuity into our physical ideas, an element that can change only in jumps, whose existence we had not suspected until a few years ago.**
Lessons

By 1913,

• Quantum theory was sufficiently established to merit several articles for non-specialist readers in Die Naturwissenschaften, including a May article by Max Born on black body theory.

• Although another four years would pass before Reiche began to publish in quantum theory, it is evident that in 1913 he had an encyclopedic knowledge of the subject.

• Finally, Reiche wrote clear, striking prose, and showed that he could present what even by 1913 was a complex, many-faceted subject to scientists at an introductory level.
Between 1913 and 1936, Reiche published some 20 book reviews in *Die Naturwissenschaften*, the majority in the teens and early 20s, and many of them on quantum theory: for example

- Arnold Eucken’s translation of the proceedings of the 1911 Solvay conference:
  
  **The actual significance, the foundations of this theory are still deeply obscure.**

- Planck’s (1908) and Wien’s (1913) lectures at Columbia University.

- Planck’s 1920 Nobel Prize lecture:
  
  **Max Planck gives ... an overview of the new wonderland that he opened up twenty years ago.**

- Books by Hermann Sieveking (1914), Siegfried Valentiner (1914, 1919), Arthur March (1919), Ludwik Silberstein (1920), and Rudolf Ladenburg (1921).
1912–1914

Publication of four books that treated quantum theory, by

- Hermann Sieveking (1875–1914)
- Siegfried Valentiner (1876–1971)
- Owen Richardson (1879–1959) (not reviewed by Reiche)

All three authors were experimental physicists.

None of the three specialized in quantum theory.

All three gave sophisticated, well informed accounts!
Hermann Sieveking (1875–1914)

- Ph.D. 1899 (Freiburg)
- ausserordentlicher Professor, Karlsruhe Technical University
- research (divided between experiment, theory) on such topics as radioactivity and electrical discharge in gases. He was also interested in airships, on which he lectured at Karlsruhe in 1913.
- had several articles in Die Naturwissenschaften, which published a 1½ page obituary
- book was based on lectures, in winter 1913, to the local chapter of the Association of German Chemists who, he tells us in the introduction, wanted to learn about "recent achievements in theoretical chemistry and physics."

- topics: electron theory, radioactivity, x-rays, relativity, and a final, thirty-page chapter on “Progress in Thermodynamics” — quantum theory (black-body radiation, Planck’s two theories, Einstein’s light quanta, Nernst’s heat theorem, specific heats of solids)

This last chapter had appeared earlier in the Proceedings of the Karlsruhe Natural Sciences Society, dated December 1912, where Sieveking tells us that it had been written even earlier for a prize on the theme “Description of quantum theory,” sponsored by the Eisenlohr Foundation.
Die Grundlagen der Quantentheorie
in elementarer Darstellung

Von
Dr. Siegfried Valentiner
Professor der Physik an der Kgl. Bergakademie Clausthal

Mit 8 Abbildungen

Anwendungen der Quantenhypothese
in der kinetischen Theorie der festen Körper und der Gase

In elementarer Darstellung
von
Dr. Siegfried Valentiner
Professor der Physik an der Kgl. Bergakademie Clausthal

Mit 4 Abbildungen

DRUCK UND VERLAG VON FRIEDR. VIEWEG & SOHN
BRAUNSCHWEIG 1914

67 pages

72 pages
Siegfried Valentiner (1876–1971)

• Ph.D. 1900 (Heidelberg)
• at Physikalisch-Technische Reichsanstalt in Berlin: 1903 paper comparing optical temperature scales with nitrogen gas thermometers
• 1906: published textbook on vector analysis (remained in print through 1960s)
• 1910: Professor at School of Mines [Bergacademie], Clausthal
• several articles in Die Naturwissenschaften (1915–1964)

• explicitly intended for beginning students
• comprehensive coverage: Blackbody radiation, light quanta, Planck’s two theories, specific heats of solids, Sommerfeld’s theory of non-periodic processes (x-rays, photoelectric effect), rotational specific heats, molecular spectra, prospects for quantizing monatomic gases (Sackur-Tetrode)
• apparently sold well; plenty of inexpensive copies are currently available on the used book market
Owen Richardson (1879–1959)

• written for graduate course at Princeton

• much less systematic treatment compared to Sieveking and Valentiner: blackbody radiation, brief discussion of specific heats of solids

• hoped that the difficulties which beset the electron theory of metallic conduction … may be overcome by the application of the ideas underlying Planck’s theory of radiation.

• He also gave what is probably the first textbook treatment of Bohr’s theory!

The Quantum Underground

Common Themes

- All three are skeptical of Einstein’s light quantum hypothesis
- All three show a marked preference for Planck’s “second theory”
- All three emphasize the importance of the photoelectric effect, and all three promote quantum (albeit not light quantum) explanations
- All three cite Walther Nernst’s February 1911 *Zeitschrift für Electrochemie* paper, “On the theory of specific heats and the lessons of energy quanta for questions in physical chemistry generally.” Sieveking and Valentiner rely heavily on it.
The Quantum Underground

My experience leads me to the opinion that scarcely half of those you envisage as participants have a sufficiently lively conviction of the pressing need for reform to be motivated to attend the conference....

Planck to Nernst
June 1910

Context: Planning for first Solvay conference that met late in 1911

By 1912–1914:

• articles/reviews in *Die Naturwissenschaften*
• Karlsruhe prize competition (!)
• books by Sieveking, Valentiner, Richardson

Quantum theory was no longer confined to the experts!

The book appears to have sold well:

- Inexpensive used copies are still widely available.
- The English translation went through three printings, the last in 1930.

1. Very few topics in quantum theory went unmentioned.
   - On unsettled questions (light quantum; Planck’s first or second theory), Reiche usually gave a careful summary, but refrained from taking sides.

2. Level was introductory:
   - main text was about 160 pages (125 pages in English translation)
   - about 50 pages of end notes, many of them extending and deepening the treatment in the text
   - historically accurate! Even today, one can get a good picture of quantum theory around 1920 from Reiche’s book.

3. As in his *Naturwissenschaften* pieces, Reiche’s writing was clear and forceful.
If we now survey the whole structure, ... we cannot avoid a feeling of admiration ... for the astonishing successes that have sprung from the quantum theory.

Nonetheless, no one who studies the quantum theory will be spared bitter disappointment. ... In spite of a comprehensive formulation of quantum rules, we have not come one step nearer to understanding the heart of the matter.

The decision has not yet been made, as to whether, as Planck’s first theory requires, only quantum-allowed states exist..., or whether, according to Planck’s second version, intermediate states are also possible. We are still completely in the dark about the details of the absorption and emission process.... Is radiation really propagated in the manner claimed by classical wave theory, or does it also have a quantum character?

Over all these problems there hovers at the present time a mysterious obscurity.

This conclusion [Planck’s quanta] is a slap in the face to classical electrodynamics....
In 1949 I was completing course work for a Ph.D. degree at New York University (NYU) but needed one additional course in statistical mechanics as a degree requirement. The course was given by a diminutive professor with a slight German accent whose name was Fritz Reiche. This course turned out to be the most memorable one I was ever to take at NYU.... The clarity, the seeming simplicity of the concepts ... succeeded in transmitting to the listener the impression that he or she was able to follow deeply and with brilliant clarity the true essence of statistical mechanics.

When reading Reiche's book I discovered, not to my surprise, that it had precisely the same flavor that I recalled from Reiche's lectures at NYU. ... It remains one of the most accessible, and substantive textbooks I have ever read.

Benjamin Bederson (2005)