The Stability of Matter in Quantum Mechanics FREE

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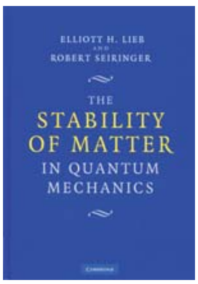
polemics. Scholars, whether on the right or the left of the political spectrum, do not serve their cause by preaching a loosely reasoned sermon to the choir. Although choir members will receive it with enthusiasm, guests in the congregation may not.

The Stability of Matter in Quantum Mechanics

Elliott H. Lieb and Robert Seiringer
Cambridge U. Press, New York, 2010. $50.00 (293 pp.).
ISBN 978-0-521-19118-0

Why is the matter around us stable? By "stability" I am not simply referring to the absolute limit on the amount of energy of an atom; every student who has taken a quantum mechanics course has solved the fundamental example of atomic hydrogen. Rather, I mean stability that makes the amount of energy proportional to the number of atomic particles and leads to the fact that two liters of fuel contain twice as much energy as one liter.



The stability of matter should primarily be an outcome of nonrelativistic quantum mechanics, since nuclear forces, radiative terms, and other non-Coulomb interactions contribute only tiny corrections to the binding energies of atoms and molecules. Quantum mechanics—given an appropriate formalism of the uncertainty principle—prevents an electron from falling into the nucleus. In addition, the distinction between fermions and bosons becomes important for systems with large numbers of particles. We now know that the binding energy would increase too rapidly with the number of negatively charged bosons and therefore violate the required energy bound, rendering bosons unsuitable for ordinary matter.

The rigorous proof showing that nonrelativistic quantum mechanics predicts stability of matter is a highlight of the application of modern mathematics to fundamental problems in physics. With their outstanding book, *The Stability of Matter in Quantum Mechanics*, mathematical physicists Elliott Lieb and Robert Seiringer provide a complete, self-contained summary of five decades of research, primarily by Lieb and his collaborators, into the stability of matter in various physical situations. Both authors are leaders in that domain.

Going beyond the stability problem in nonrelativistic quantum mechanics, the authors also model the corresponding quantum mechanical systems with relativistic kinematics. Although only toy models, they are frequently used for calculations of atomic and molecular energies. In relativistic quantum mechanics, a new feature occurs: The product of the charge of the nucleus and the fine structure constant must be bounded to ensure the finiteness of the energy. The stability of large systems also implies a bound on the fine structure constant, which characterizes the strength of the electromagnetic interaction. The authors also take into account gravitational interactions, in which can be seen an even more spectacular result: Stars collapse under gravity, and their critical mass—above which they become unstable—depends on the gravitational constant.

The discussions of those and other topics make the book a rich source for research into related fields. However, *The Stability of Matter in Quantum Mechanics* is also for students of mathematics and physics, not just for researchers. Since deep and beautiful mathematical techniques and results are needed, the required mathematical level is certainly high. But students should not be discouraged because the book's pedagogical style carefully guides them through the physical concepts and relevant mathematics before putting all the pieces together. Students and teachers alike will enjoy a marvelous experience as they learn from *The Stability of Matter in Quantum Mechanics*.

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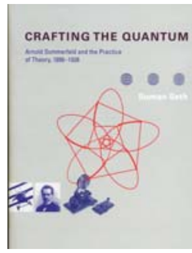
Crafting the Quantum
Arnold Sommerfeld and the Practice of Theory, 1890–1926

Suman Seth
MIT Press, Cambridge, MA, 2010.
$32.00 (378 pp.).
ISBN 978-0-262-01373-4

Arnold Sommerfeld (1868–1951) was appointed to the chair for theoretical physics at the University of Munich in 1906; he was recommended by his colleague Wilhelm Röntgen to fill that post, which had been vacant since Ludwig Boltzmann moved back to his native Vienna in 1893. In the first quarter of the 20th century, Sommerfeld corresponded with the leading physicists of the day, including Max Planck, Woldemar Voigt, and Albert Einstein. He also corresponded with the younger contemporary mathematical physicists, as theoretical physicists were then usually called, including Max Born, Niels Bohr, and Erwin Schrödinger.



In writing *Crafting the Quantum: Arnold Sommerfeld and the Practice of Theory, 1890–1926*, Suman Seth has mined those correspondences extensively. A historian of 19th- and 20th-century physical science at Cornell University, Seth traces Sommerfeld's roots in applied mathematics, which led to his rise in theoretical physics. After completing his dissertation under mathematician Ferdinand von Lindemann at Albertina University in Königsberg, East Prussia, Sommerfeld carried out his postdoctoral work as a member of the entourage of mathematicians David Hilbert and Felix Klein at the University of Göttingen; he collaborated with Klein on the four-volume, 966-page applied-mechanics treatise *Über die Theorie des Kreisels* (*On the Theory of the Gyroscope*).

Sommerfeld's other early publications were on hydrodynamics and the theory of lubrication, wireless telegraphy, and oscillations in coupled AC circuits; one paper was entitled "Zur Theorie der Eisenbahnbremsen" ("On the Theory of Brakes on Railroad Cars"). He also taught applied mathematics to engineers at postsecondary technical institutions in western Germany before he was called to chair the Munich theoretical physics department. Too old to be drafted during World War I, Sommerfeld worked on problems of radio telegraphy and ballistics for the Kaiser Wilhelm Foundation for War Technology and Science (which disappeared after World War I). Indeed, the path of Sommerfeld's career showcases the close link between pure and applied physics.

Seth argues that advances in theoretical physics are characterized by two contrasting approaches: applying general laws and principles to physical phenomena, as Einstein did with relativity and Planck did with thermodynamics, and using experiments,