

Abstract

The rotational specific heat of molecular hydrogen in the old quantum theory

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“Astonishing successes” and “bitter disappointment”: Thus did the German physicist Fritz Reiche portray the state of quantum theory in his 1921 text. His words apply in miniature to early descriptions of the decrease in the specific heat of hydrogen gas at low temperatures—among the first systems studied in the old quantum theory. The first measurements were made in 1912 by Arnold Eucken in Walther Nernst's laboratory in Berlin. The possibility of applying a quantum theory of rotators to diatomic gases was raised even earlier by Nernst, and figured in the discussions at the first Solvay conference late in 1911. Eucken's experiment was the first of many. Albert Einstein, Paul Ehrenfest, Edwin C. Kemble, Niels Bohr, John Van Vleck, and Erwin Schrödinger, among others, attempted theoretical descriptions of the rotational specific heat, as did Reiche himself in a widely cited 1919 paper. Despite these efforts, the problem proved intractable—its explanation involves identical particles in ways unsuspected before modern quantum mechanics. To make matters worse, the old quantum theory worked fairly well to describe infrared spectra of diatomic molecules such as HCl—and in the process, made the specific heat measurements even more puzzling. Later in the 1920s, measurements of electronic transitions in the spectrum of molecular hydrogen further complicated matters. I will sketch the history of this intriguing problem in early quantum theory.