GP 11: The tools of physical theory

Zeit: Mittwoch 14:00–16:30 Raum: HS 9

GP 11.1 Mi 14:00 HS 9

The Fresnel wave surface in the 1820s and 1830s: physical tool or object of mathematical study? — •Marta Jordi Taltavull — Johannes Gutenberg Universität Mainz

In 1821 Augustin Fresnel proposed that the propagation of light through biaxial crystals could be described by a special kind of surface, which is nowadays called the Fresnel wave surface. Biaxial crystals had posed a very challenging problem for optics ever since the 17th century, for light passing through them did not follow the ordinary laws of light propagation. The Fresnel surface became a tool to describe and understand better this anomalous behavior.

Yet Fresnel wave surface did not just remain a tool. Mathematicians and natural philosophers, in particular James MacCullagh, William R. Hamilton and Julius Plücker, turned their attention to the Fresnel surface as an object of mathematical study in the 1830s. They embedded it into more general mathematical theories, such as inversive geometry, and analyzed its properties as a mathematical surface. Relying on such properties, Hamilton even predicted a new optical phenomenon, conical refraction. Later, the Fresnel surface became just one instantiation of a special class of a more general kind of mathematical surfaces called quartics.

Thus the Fresnel wave surface had acquired a life on its own beyond biaxial crystals, having changed from tool in physics to object of study in mathematics, while mediating between both physical and mathematical cultures.

GP 11.2 Mi 14:30 HS 9

The Correspondence Principle as a Research Tool: Rethinking the Old Quantum Theory — •Martin Jähnert — TU Berlin

In a classical assessment, Max Jammer described the old quantum theory as a "lamentable hodgepodge of hypothesis, principles, theorems and computational recipes." This conglomeration of theoretical tools, he diagnosed, constituted a conceptually flawed mix of classical and quantum concepts and was therefore intrinsically doomed to failure. Decades have gone by, in which the philosophy and history of science developed a much more balanced take on the role of theoretical tools in physics, yet Jammer's assessment and the associated narrative of a crisis of the old quantum theory remains largely intact.

In this talk, I will reexamine multiple approaches within the old quantum theory, which operated with a set of loosely interconnected tools while building on a shared conception of quantum systems. I will show how the transfer of these theoretical tools into new empirical domains, their integration into existing theoretical representations and their implementation changed the tools themselves. This transformation through implementation, I will argue, played a central role in the emergence of quantum mechanics and provides the basis for reassessing the old quantum theory and its development.

GP 11.3 Mi 15:00 HS 9

'The new conception of the postulates:' The Bohr-Kramers-Slater reformulation of the (old) quantum theory — •Daniel J Mitchell — Institüt für Theoretische Teilchenphysik und Kosmologie, RWTH Aachen, Sommerfeldstr. 16, 52074 Aachen

The so-called Bohr-Kramers-Slater (BKS) quantum theory remains the subject of conflicting interpretations among historians owing in part to the confusing ontological status of the 'virtual oscillators' (VOs) and 'virtual radiation' (VR) that it introduced. Are these just metaphors—semantic tools, if you will—for describing existing theoretical practice, or do they signify an alternative model to the state-transition picture of the atom? If so, should it be interpreted realistically, or merely as a classical tool for constructing phenomenological relationships between quantum-theoretical quantities? What is it about BKS that made, and continues to make, it so intractable? One reason is a failure to follow up on the main actors' pronouncements about their own work. Another is a narrow focus upon the theoretical content of the ambiguous joint BKS paper of early 1924 rather than its (albeit short-lived) development into 1925. Drawing partly upon recent scholarship on dispersion theory and the correspondence principle, I reconceptualize BKS as an extension and reformulation of Bohr's postulates of quantum theory. I then go on, in the context of the specific prohibition of causal space-time pictures, to characterise the several distinct senses in which the VR and VOs served as tools for articulating these postulates. This perspective, I argue, better represents how Bohr, Kramers, and Slater themselves perceived and pursued 'BKS.'

GP 11.4 Mi 15:30 HS 9

A History of Kirchhoff's Law of Thermal Emission — •Pierre-Marie Robitaille[1] and Stephen Crothers[2] — [1]The Ohio State University, Columbus, OH — [2]Tasmania, Australia

In 1859, Gustav Kirchhoff advanced his Law of Thermal Emission stating that within any arbitrary opaque cavity, in thermal equilibrium, the radiation will always be black, or normal, dependent only on temperature and frequency, while being independent of the nature of the wall. Kirchhoff's proposed this law based solely on theoretical arguments and without experimental proof. Yet, since that time, no theoretical proof of Kirchhoff's law has survived, as Hilbert highlighted at the beginning of the 20th century. Furthermore, this now includes the proof advanced by Max Planck himself [1]. At the same time, no experimental proof of Kirchhoff's law exists. This is because, perfectly reflecting cavities are designed to be resonant. Quality factors for laser cavities have now achieved values of 10^{11}. Conversely, unlike rigid perfect reflectors, actual black bodies are able to do work, transforming any incident energy (either as photons or heat) into normal radiation manifesting the equilibrium temperature. Perfect reflectors can never achieve such a feat (unable to emit) and are in fact, completely uncoupled from the radiation field. In this talk, the history of black body radiation will be reviewed beginning with work preceding Kirchhoff until present. It will be demonstrated that Kirchhoff's Law is indeed false and that universality does not exist. The consequences for modern physics will also be discussed. [1] P.-M. Robitaille and S. Crothers, Progress in Physics, v. 11, p.120-132, (2015).

30 min. coffee break