From Classical to Quantum Optical Dispersion, after Bohr's Atom

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Abstract:

The talk will be on the transition between classical theory of optical dispersion and its first satisfactory quantum explanation in 1921, during the period after the appearance of Bohr's atom in 1913. It is well known that quantum optical dispersion was crucial for the origin of matrix mechanics in 1925 (Duncan and Janssen, 2007), but there is scarcely secondary literature on its development from classical picture, within the context of old quantum physics.

Optical dispersion is a physical phenomenon in which the phase velocity of light, when it passes through a medium, depends on its frequency. This causes the splitting of light into different colors. According to classical theory, such phenomenon was due to the interaction between wave light and particles of matter vibrating harmonically at some proper frequencies. If the frequency of incoming light coincided with one of those proper frequencies, light was absorbed. In quantum physics, on the other hand, such characteristic frequencies of matter were not considered vibration frequencies of particles but transitional frequencies between two energy levels within Bohr's atom. This was the crucial conceptual difference between classical and quantum theories of optical dispersion, that is, the assumption that observed absorption frequencies in dispersion experiments were the transitional frequencies between two different levels within the atom. Rudolf Ladenburg was the first, in 1921, in analyzing the phenomenon in such terms, 8 years after Bohr proposed his model of atom.

In the years in between, specifically 1915-1917, Arnold Sommerfeld, Peter Debye and Clinton Davisson also attempted to account for optical dispersion on the basis of Bohr's atom. However, they did not consider proper frequencies as transitional frequencies, but as orbiting frequencies of electrons around the nucleus, which entailed a physical picture of interacting light and matter different from the one accepted for explaining spectra. That caused strong criticisms from Niels Bohr himself, Paul Epstein and Carl Wilhelm Oseen in the subsequent years.

In the talk I will analyze Sommerfeld, Debye, Davisson and Ladenburg different explanations and pictures of light-matter interaction in optical dispersion, by paying special attention to their physical motivations, both from experimental and theoretical sides, in a context of emerging quantum physics.