“Classical" Solutions to the Challenges of Radiation and its Interaction with Matter

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Abstract:

The discovery of x-rays and gamma rays at the end of the nineteenth century, and the earlier discovery of the interaction between ultraviolet light and matter (photo-electricity) opened up quite a few questions for their researchers. Unlike the questions that followed form most of the phenomena discovered at the nineteenth century, some of these questions (and their connection) proved with time a challenge for the extant concepts of electromagnetic radiation and of particles. Yet, initially physicists accounted for the new phenomena with ideas and concepts from the physics of the previous century (“classical physics”). In this vain G.G. Stokes and others explained x-rays as electromagnetic impulse of waves within the Maxwellian framework. However, these basically continuous theories led to what Bruce Wheaton called the paradoxes of quantity (why only a small number of particles interacts with the radiation) and quality (how does the radiation provide energy of the same order of magnitude needed to produce it). Early answers, or partial answers, to these paradoxes continued to exploit older ideas. E.g., J. J. Thomson returned to Faraday’s tubes or fields of force, to explain localization of the radiation’s energy. This “corpuscular” idea was well known in the Anglo-Saxon world, and was sometimes conflated with Einstein’s quantum theory. Lenard employed the idea of resonance between two periodic phenomena to account for the effect of light on matter. According to his and to similar theories, light only triggers the release of electrons from the matter (photo-electricity and related phenomena). However, accumulation of experimental data around 1910 cast doubts on triggering theories.

The rejection of triggering theories, however, did not entail acceptance of Einstein’s light quantum hypothesis, which originated from his considerations of black-body radiation. At the early 1910s, the quantum hypothesis was used by other researchers (Planck, Sommerfeld, Debye and Richardson) to account for photoelectricity. Yet, in their hands, the assumption did not include discontinuity of radiation. Their theories, however, were unsatisfactory due to disagreement with experiment, or luck of explanatory power. The accumulation of many experimental findings on the behaviour of electromagnetic radiation led most physicists to consider the interaction of light and matter as an open question, required a general explanation. At the same time they rejected Einstein’s light quantum.