PAPER 5

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On a Heuristic Point of View Concerning the Production and Transformation of Light

A PROFOUND formal difference exists between the theoretical concepts that physicists have formed about gases and other ponderable bodies, and Maxwell's theory of electromagnetic processes in so-called empty space. While we consider the state of a body to be completely determined by the positions and velocities of an indeed very large yet finite number of atoms and electrons, we make use of continuous spatial functions to determine the electromagnetic state of a volume of space, so that a finite number of quantities cannot be considered as sufficient for the complete determination of the electromagnetic state of space. According to Maxwell's theory, energy is considered to be a continuous spatial function for all purely electromagnetic phenomena, hence also for light, whereas according to the present view of physicists, the energy of a ponderable body should be represented as a sum over the atoms and electrons. The energy of a ponderable body cannot be broken

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up into arbitrarily many, arbitrarily small parts, but according to Maxwell's theory (or, more generally, according to any wave theory) the energy of a light ray emitted from a point source continuously spreads out over an ever-increasing volume.

The wave theory of light, which operates with continuous spatial functions, has proved itself superbly in describing purely optical phenomena and will probably never be replaced by another theory. One should keep in mind, however, that optical observations refer to time averages rather than instantaneous values; and it is quite conceivable, despite the complete confirmation of the theory of diffraction, reflection, refraction, dispersion, etc., by experiment, that the theory of light, operating with continuous spatial functions, leads to contradictions when applied to the phenomena of emission and transformation of light.

Indeed, it seems to me that the observations of "blackbody radiation," photoluminescence, production of cathode rays by ultraviolet light, and other related phenomena associated with the emission or transformation of light appear more readily understood if one assumes that the energy of light is discontinuously distributed in space. According to the assumption considered here, in the propagation of a light ray emitted from a point source, the energy is not distributed continuously over ever-increasing volumes of space, but consists of a finite number of energy quanta localized at points of space that move without dividing, and can be absorbed or generated only as complete units.

In this paper I wish to present the train of thought and cite the facts that led me onto this path, in the hope that the approach to be presented will prove of use to some researchers in their investigations.

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1. On a Difficulty Concerning the Theory of "Black-Body Radiation"

We shall begin by considering the following case from the perspective of Maxwell's theory and electron theory. Let a space enclosed by completely reflecting walls contain a number of freely moving gas molecules and electrons that exert conservative forces on each other when they come very close, i.e., can collide with each other like molecules according to the kinetic theory of gases.[1] Suppose, further, that a number of electrons are bound to widely separated points in space by forces directed toward these points and proportional to their distances from them. The bound electrons also enter into conservative interactions with the free molecules and electrons when the latter come very close. We call the bound electrons "resonators"; they emit and absorb electromagnetic waves of definite periods.

According to the present view concerning the origin of light, the radiation in the volume we are considering, as is found for the case of dynamic equilibrium based on Maxwell's theory, must be identical with "black-body radiation"—at least if one assumes that resonators of all relevant frequencies are present.

For the time being, we will disregard the radiation emitted and absorbed by the resonators and investigate the condition of dynamic equilibrium corresponding to the interac-

[1] This assumption is equivalent to the supposition that the mean kinetic energies of gas molecules and electrons are equal to each other at thermal equilibrium. As is well known, Mr. Drude used the latter assumption to derive a theoretical expression for the ratio of thermal and electrical conductivities of metals.

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