Maxwell and Imaginary Physics

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We focus on the use of imagination in physics, specifically in electromagnetism. The term "virtual" is not mentioned, but "imagination" is explicitly invoked as a technical term.

James Clerk Maxwell's first contribution to the study of electromagnetism is revolutionary. In his paper "On Faraday's lines of force" (1856–1858), Maxwell transformed the traditional methodology of analogy, expanded by William Thomson, into a powerful new technique which draws a parallel between a set of physical phenomena and an **imaginary arrangement**, entirely contrived by the physicist.

Maxwell pursued in this paper what he called "physical analogy". On all accounts this was an original move, unheard of at the time, for Maxwell extended physics into the realm of imagination where he could control the physics as he wished with the goal of recasting the experimental discoveries of Faraday into mathematical formalism. The move is not about a simplified version of reality; it is thus neither about idealization nor about abstraction; rather, Maxwell introduced an entirely imaginary system. Thomson had analogies between different physical systems based on their mathematical descriptions where the same set of equations applies to two different domains of physics. By changing the meaning of the variables and the constants in the equations in one system, one gets immediately the equations that apply in another system; hence, consequences of the equations apply to all systems described by the same set of equations, and can be checked experimentally. Maxwell ingeniously modified this scheme and introduced an analogy between a physical system and an imaginary system, where the same set of equations applies. He invented, or rather "imagined", to use his word, a new kind of physics along the guidelines he discussed, and then used it in an analogy in order to develop a new formalism.

The move was to imagine lines of force as tubes, fill them with an imaginary imponderable and incompressible fluid complete with sources and sinks. The fluid then permeates a medium whose resistance is directly proportional to the velocity of the fluid. The intention was to apply mathematical ideas obtained from the flow of the imaginary fluid to various parts of electrical science. Maxwell then developed an imaginary hydrodynamics to turn the geometrical scheme of Michael Faraday into a "physical" one, which now included both the direction of the force and its intensity. This novel imaginary physics served as an analogue which, in turn, facilitated the construction of a new formalism. It was assumed as a vehicle of mathematical reasoning.

We call this methodology "contrived analogy", for Maxwell constructed an analogy which was only of interest in one direction: from his imaginary physical scheme to the physics of electromagnetism. Thomson invoked analogies that work in both directions, but Maxwell had analogies that work either in both directions or in one direction. This was an important modification which enriched substantially the methodology of analogy. This usage of "imaginary" in physics was unprecedented.