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The Conversion of Phenomena to Theory: Lessons on Applicability from the Early Development of Electromagnetism

Many considerations of the problem of the applicability of mathematics, focusing on 20th century physics, have found the successful application of abstract mathematics to physical theory in that century mysterious. A notable example is Mark Steiner who has argued that the success of the forms of argumentation used to develop quantum theories, many of which are kinds of mathematical analogy, apparently defies naturalistic explanation. Insight into the reasons for the successful application of mathematics can be gained, however, through an examination of the development of earlier theories. The consideration of 19th-century physics is of particular interest since not only is this the century that saw the rise of many of the theories that would form the foundation for the development of 20th-century physics, but it is in this century that physicists began to understand how to use mathematics to understand what the world is like underneath the phenomena of experience. In this paper I will examine a key period in the early development of electromagnetic theory, namely the conversion of the available knowledge of the phenomena, knowledge developed in large measure by Faraday, into a mathematical theory, primarily in the work of William Thomson and Maxwell. An examination of this episode clarifies how knowledge of phenomena is converted into a crystallized mathematical form, which provides clues as to how to account for the apparently mysterious success of mathematics as applied to 20th-century physics.