

Author's Preface to the Green Lion Edition (2010)

Perhaps the chief aspect of *Maxwell's Mathematical Rhetoric*, and the source of the importance of its other aspects, is its conception as a *literary* study of Maxwell's *Treatise*, that is, its assumption that the *Treatise* must be approached as a work of literature, whose contribution is not merely to "science" narrowly defined, but to the unfolding stream of human thought. In short, *Maxwell's Mathematical Rhetoric* represents an attempt at reading Maxwell's *Treatise* as a great book.

This literary reading reveals that Maxwell himself wrote with an expressed interest in questions of rhetoric—particularly of mathematical rhetoric. Maxwell writes with an evident intent to shape new mathematical forms, designed to lead the reader to new conceptual approaches to the natural world. What results is a strong reaffirmation in practice of the concept of natural philosophy, as distinct from merely technical scientific advance. This yields a number of important features.

First among them must be Maxwell's dramatic turn to the Lagrangian form in which to present the concept of the electromagnetic field and, in the same mode, to reveal the electromagnetic theory of light. Narrow readings of the *Treatise* have regarded this as a mere matter of convenience, or even whim, on Maxwell's part. Critics have been slow to catch the fundamental difference between a Newtonian and a Lagrangian world view. It is true that under proper conditions, Lagrange's equations can be derived from Newton's, and vice versa. But from the standpoint of Maxwell and the *Treatise*, this by no means renders them equivalent! Lagrange addresses a world in which the cosmos is whole and connected; Newton, a world of isolated particles acting upon one another over distances. Lagrange's equations appear in the *Treatise* as the culmination of a long series of rhetorical moves, including (among others) Green's theorem, Gauss's potential theory, and Faraday's lines of force—all of which have prepared the reader for the Lagrangian vision of a natural world that is whole and connected: a veritable sea-change from Newton's vision.

One indication that the *Treatise* is truly a literary work is our increasing awareness as we read that we are witnessing an unfolding portrait of Faraday as thinker, researcher, and unassuming human being. Maxwell's devotion to Faraday is undisguised and consistent, even to the formulation

of the equations of Maxwell's final theory: Faraday's "exploring wire"¹ persists as a paradigm for *envisioning* relationships which the equations express in analytic terms. The new world that Lagrange describes requires investigators like Faraday, not like the "high mathematicians" of the universities. Despite Maxwell's gentle style, his *Treatise* must be read as an act of quiet defiance—a call to transform at once the concept and content of science, as well as the character of its practice and practitioners.

Curiously, scholars have failed to notice that the *Treatise* thus constitutes a watershed event, a dialectical moment in the history of science with wide-ranging implications for society as a whole. Maxwell is—perhaps a bit slyly—aware of such implications as he writes the *Treatise*. Ostensibly, he is writing the text that will implement a new Tripos component on electricity and magnetism at Cambridge, and the *Treatise* does achieve that important goal. But Maxwell quite evidently has also something else very much in mind, for in focusing on Faraday he is celebrating a scientist of a very un-academic sort, alien to the halls of Cambridge and its mathematical ways, intimately in touch with nature by way of experiment, and deeply averse to the lofty theory of Newton's *Principia*. Equally unorthodox is Maxwell's turning to Bacon and adopting that rhetorician's notion of "experiment of illustration."

Other projects express a similar spirit of reform. Maxwell will soon be engaged in reducing (perhaps we should say "elevating") the *Treatise* to its true elements in a new *Elementary Treatise on Electricity and Magnetism*. This, though never completed, is meant to take its place beside other elementary treatises, such as *Matter and Motion*, which he has written over the years to implement courses he has taught for working people. And he will soon be conniving with the Duke of Devonshire to build a new teaching laboratory (the Cavendish) where, over the opposition of the University faculty, he will implement within the hallowed halls of Cambridge a new program in *experimental* natural philosophy. Like other watershed events in the history of the sciences, the *Treatise* carries social and political implications reaching far beyond the sciences themselves, at least as they are commonly understood.

A certain moment in the *Treatise* deserves special attention, both as representing Maxwell's quiet yet potent literary style, and his own characterization of the watershed the *Treatise* is traversing. This is the chapter in which Ampère and his elaborate mathematical theory—intricately contrived to preserve the form and spirit of Newton—is contrasted with the modest approach of Faraday, who, innocent of such mathematical formalities, listens to nature and painstakingly follows her ways. Maxwell, who magically turns Ampère's theory into Faraday's in the course of the chapter, clearly delights in this contrast between the way of the aristocrat of science, and

1. See, for example, Faraday's *Experimental Researches in Electricity*, Twenty-eighth Series.

the ways of this uncommon common man, unmathematical, but keenly observant, who thinks in a different, far more effective, mode. It might not be altogether out of order to see in this move an ironic Scottish rebellion against the pretensions of British aristocracy; but its implications are not so limited. Maxwell himself is curiously positioned as at once agent and reporter of his revolution, living, as he literally was, in both camps.

All this is interesting as pertaining to England of the 19th century, but its interest is multiplied by its application to pressing issues of our own time. The text of *Maxwell's Mathematical Rhetoric* may be forgiven for not having anticipated developments which ensued forty years after its composition. In any case, the question of "wholeness" in physical theory is very much before us today, and our inability to deal effectively with whole systems has become a matter of urgent importance.

The problem is evident in many arenas of a now hugely interconnected world, but it will be sufficient here to speak of our increasing awareness of the interconnectedness of our environment, from local ecosystems to the atmosphere and biosphere. As a result, theorists today are making the same move Maxwell made in the *Treatise*, away from the Newtonian paradigm in which systems are understood as force-coupled assemblages of separate parts—still the commonplace of physicists and biologists alike—to the Lagrangian alternative in which the wholeness of a system becomes the starting point for thought and for an investigation characterized in terms of energy exchanges and material flows. Today, Lagrange's equations are regularly invoked to characterize such processes, often in conjunction with a first-order term representing the second law of thermodynamics. Strong light is thus focusing on the very dialectical turn that is the central theme of the *Treatise*, though generally with insufficient sense of its true meaning or importance. Might this not be an excellent time for us to turn to Maxwell for considered advice about the significance of the path on which we are embarking, and the importance of the decision now in our hands?