

Cambridge University Press

052100585X - The Natural Philosophy of James Clerk Maxwell

P. M. Harman

Frontmatter

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## The Natural Philosophy of James Clerk Maxwell

This book provides an introductory yet comprehensive account of James Clerk Maxwell's (1831–1879) physics and worldview. The argument is structured by a focus on the fundamental themes which shaped Maxwell's science: analogy and geometry, models and mechanical explanation, statistical representation and the limitations of dynamical reasoning, and the relation between physical theory and its mathematical description. This approach, which considers his physics as a whole, bridges the disjunction between Maxwell's greatest contributions: the concept of the electromagnetic field and the kinetic theory of gases. Maxwell's work and ideas are viewed historically in terms of his indebtedness to the scientific and cultural traditions, of Edinburgh experimental physics and of Cambridge mathematics and philosophy of science, that nurtured his career.

PETER HARMAN is Professor of the History of Science at Lancaster University. He is the editor of *The Scientific Letters and Papers of James Clerk Maxwell* (also published by Cambridge University Press). The present book derives from his lectures as Zeeman Visiting Professor of the History of Physics at the University of Amsterdam.

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#### Reviews from the hardback edition

‘By stressing the deep traditionalism of Maxwell’s enterprise, Harman makes him a participant in a philosophical conversation about matter, motion and mind, well-established by the time of Newton and continuing into this century.’

Simon Schaffer, *London Review of Books*

‘The sections on Maxwell’s physics in this book are presented with admirable clarity, particularly the intricacies of how his theory of electromagnetism developed, which are usually difficult to follow. This presentation gives the general reader a clear overview of Maxwell’s work, while the discussion of how Maxwell’s physics developed with time provides a good insight into how philosophical ideas matured.’

Elizabeth Garber, *Physics World*

‘... not the least of his talents is his ability to present brief, informed, and intelligible accounts of the results of [technical] analysis and use them in his argumentation.’

Ole Knudsen, *Centaurus*

‘The book is wonderfully informative and insightful throughout; its merit lies as much in stimulating questions as in providing answers.’

Daniel Siegal, *American Scientist*

‘“Natural Philosopher” probably captures as much of Maxwell as any single label can, and Harman is to be commended for bringing a measure of synthesis to our picture of one of the most important but elusive figures of Victorian science.’

Bruce J. Hunt, *Isis*

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For my mother and in memory of my father

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## Preface

This book is based on lectures I delivered in spring 1995 at the University of Amsterdam, as Zeeman Professor of the History of Physics. I am very grateful to the Pieter Zeeman Foundation, and especially to Anne Kox, for this generous invitation. On revising the text for publication I have retained traces of its original presentation as a series of lectures, as an aid to clarity of exposition. I have aimed to provide an introductory yet comprehensive account of Maxwell's science and worldview, intended to be accessible to readers without specialised knowledge bearing on its subject.

The traditional term 'natural philosopher' may be aptly applied to a scientist who was also a scholar, deeply conscious of the historical roots and philosophical import of his physics. The chapters of this study are structured by the broad categories which shape Maxwell's natural philosophy: analogy and geometry, mechanical and statistical representation. Maxwell's work and ideas are located historically in terms of his indebtedness to the cultural and scientific traditions, of Edinburgh experimental physics and metaphysics, and of Cambridge mathematics and philosophy of science, that nurtured his career and intellectual development.

Historians of physics have traditionally described Maxwell's science by writing from the perspective of one or other of the two main fields of physics which he revolutionised: the theory of electromagnetism ('Maxwell's equations') and the electromagnetic theory of light, and the kinetic theory of gases and statistical physics. Some excellent work has been accomplished within this constraint, and this frame of reference is appropriate if the concern is with the development of 'Maxwell's equations' or his statistical methods in mathematical physics. But there has been little attempt to consider Maxwell's physics as a whole intellectual endeavour. In defining the historical Maxwell in terms of topics in physics, these studies have been based on a very restricted range of sources, and this has led to a limited reading of his intentions.

In seeking to provide a more comprehensive interpretation of Maxwell's intellectual outlook and practice, the argument here is based on study of the whole range of his writings. This book focuses on the fundamental themes of Maxwell's natural philosophy. It is not a biography or an account of Max-



## Preface

well's career, though the presentation is broadly chronological and attention is paid to the scientific and cultural context. Nor does it provide minute analysis of special points of physics, though the argument is, on occasion, technical.

The argument draws extensively upon the manuscript materials collected in my edition of *The Scientific Letters and Papers of James Clerk Maxwell*, and provides a supplementary commentary to that edition, giving a more general and systematic account of Maxwell's science than is possible in the introductions to its volumes. To avoid burdening this book with an excessive scholarly apparatus, wherever appropriate, reference is made to the extensive editorial annotations in *Letters and Papers*, but the citations in the text and endnotes provide necessary documentation.

To date, two of the three planned volumes of *Letters and Papers* have been published; archival references are given in the endnotes for manuscripts which will be printed in its final volume. For permission to include these documents and to reproduce photographs in the plates I am grateful to the Syndics of the Cambridge University Library, the President and Council of the Royal Society, and the Cavendish Laboratory, Cambridge.

I appreciate my continued association with Cambridge University Press, and thank Simon Mitton for his kind encouragement; and I owe a debt of gratitude to Susan Bowring for her meticulous work as copy-editor. This book is a product of research carried out in the preparation of *Letters and Papers*, and I thank the Council of the Royal Society for a succession of research grants which have supported this project. But it has its origin in work I began many years ago, and I gratefully recollect the generous encouragement I received then, especially from Ted McGuire. For granting me leave of absence to assist its completion I am grateful to colleagues in the Department of History at Lancaster University.

## Abbreviations

The following abbreviations are used in the text for references to frequently cited works. Citations are by volume, page, and (where appropriate) section numbers.

*LP*

*The Scientific Letters and Papers of James Clerk Maxwell*, ed. P. M. Harman, 2 vols. to date (Cambridge, 1990, 1995)

*SP*

*The Scientific Papers of James Clerk Maxwell*, ed. W. D. Niven, 2 vols. (Cambridge, 1890)

*Treatise*

James Clerk Maxwell, *A Treatise on Electricity and Magnetism*, 2 vols. (Oxford, 1873)

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# Plates

- I Saturn's rings model, 1858 (Cavendish Laboratory, Cambridge) p. 58
- II Drawing of electrical torsion balance, 1 March 1865 (University Library, Cambridge, Add. MSS 7655, V, c/14(i)) p. 66