Maxwell: Giant Shoulders to Stand Upon; A "Mysteriously Prescient" Intellect

The Natural Philosophy of James Clerk Maxwell

Peter M. Harman
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Reviewed by C. W. Francis Everitt

Few people succeed in altering the nature of any science. We physicists are fortunate to be working in one in which the historical perspective is so long and clear that we can confidently recognize the giants on whose shoulders we stand.

James Clerk Maxwell brought about not one but two distinct revolutions in physics. The first was his introduction of statistical methods into the foundations of physics via the kinetic theory of gases. The second was the unification he effected between electricity, magnetism, and light. In *The Natural Philosophy of James Clerk Maxwell*, Peter Harman explores both and allows us to experience a mind so mysteriously prescient as to see truths decades before anyone else did and so incisive as to be incapable of writing a single dull sentence. Harman is the author of a notable book on 19th-century physics, entitled *Energy, Force and Matter* (Cambridge U. P., 1982), and the editor of a distinguished collection of Maxwell's unpublished writings. (*The Scientific Letters and Papers of James Clerk Maxwell*, Volumes 1 (1990) and 2 (1995); others in process; Cambridge U. P.) As such, he is well placed to help us in this encounter.

Natural philosophy is, as Maxwell said, "the good old English name for what is now called Physical Science." However, Harman rightly uses the term in another sense: Maxwell was a trained philosopher, and all his thinking about physical reality bears the stamp of his philosophical training.

Maxwell's education was rich. Brought up in Edinburgh, he enjoyed Scotland's traditional broad liberal-philosophical schooling. Then, at 19, he migrated to Cambridge University for the trial by ordeal of its famously ferocious mathematical *tripos* (Cambridge's final honors examination in mathematics). Thereafter, for the rest of his life, he oscillated between Scotland and England and, as the heir to a large country estate, he was able to retire from academic life for six years, beginning when he was 34, to write his *Treatise on Electricity and Magnetism*.

Maxwell's philosophical mentors were William Hamilton at Edinburgh and William Whewell at Cambridge. Harman gives a penetrating discussion of Whewell's deeply influential and too-little-appreciated notions of the "consilience of inductions" and "appropriate ideas." As for Hamilton, physicists may be surprised to learn that this half-forgotten philosopher (no relation to the Irish mathematician of the same name) is the man responsible for inventing the word "relativity." One of Hamilton's main doctrines was the "relativity of human knowledge," that is, the partly Kantian idea that we have knowledge not of objects in themselves but rather of relations between them. It is fascinating to see how that view affected Maxwell's thinking about electromagnetism and light. Through Maxwell's little masterpiece *Matter and Motion* (1876), this previously recondite philosophical term "relativity," suddenly entered physics. From there it flowed first to Henri Poincaré and to French and then German physics—and so to Albert Einstein.

As Harman points out, most writers on Maxwell have treated his two revolutions as intellectually independent events. In his most original chapter, "Dynamical and Statistical Explanation," Harman makes a valuable beginning on the difficult task of weaving the two together. In each, the key was a willingness to operate with incomplete knowledge. Maxwell found a way of describing the electromagnetic field dynamically in terms of a Lagrangian without any detailed hypothesis about the underlying mechanics, and he perceived that, in studying the dynamics of large numbers of molecules, one can formulate a method of treatment that is statistical and therefore incomplete but still enormously fruitful scientifically. It is curious that choosing the right thing to be ignorant about is the way to learn something. This philosophical dynamic has, as we know, continued to animate 20th-century physics.

Harman tells his tale skillfully, with an admirable use of quotations from Maxwell's published and unpublished writings. One characteristic of Maxwell that is not fully conveyed is the electric quality of his mind. Yet this is what impressed and sometimes intimidated those who met him. In this centennial year of the American Physical Society, it is nice to recall what Henry Augustus Rowland wrote in 1875 to Daniel Gilman, the president of Johns Hopkins University, after an extended visit to Europe, during which he spent several days with Maxwell at his home in Scotland. As for most of the professors, Rowland wrote, "They are men like the rest of us," but "after seeing Maxwell, I felt somewhat discouraged, for here I met a mind whose superiority was almost oppressive."

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Theoretical Global Seismology

F. A. Dahlen and Jeroen Tromp
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Seismology involves the analysis of vibrations of Earth that occur when energy is released by a variety of natural and human-induced sources. The vibrations, preserved as seismograms by ground-motion recording instruments, reveal many attributes of both the source excitation and the section of Earth through which the elastic waves have propagated.

As does any medium of finite dimensions with nearly elastic equations of internal motion, Earth has an infinite set of distinct normal modes of oscillation that sum, with appropriate linear weighting factors, to comprise any vibration of the system. Thus, one of the most elegant approaches to understanding seismic recordings involves their analysis in terms of normal modes of Earth. This approach underlies many techniques now in routine