**Skulls in the Stars**

*The intersection of physics, optics, history and pulp fiction*

# Maxwell on Faraday

Posted on July 25, 2009 by skullsinthestars

I'm working on a few longer posts at the moment, but in the meantime I thought I'd share a nice little passage I came across while looking through James Clerk Maxwell's *A Treatise on Electricity and Magnetism* (1873). Maxwell, of course, was the scientist who theoretically put together, for the first time, a complete set of equations of electricity and magnetism, the eponymous Maxwell's equations, and also used these equations to postulate that light is an electromagnetic wave.

I've blogged a lot about the accomplishments of Michael Faraday, who did most of the experimental legwork which allowed Maxwell to make his discovery. This relationship was not lost on Maxwell, who had nothing but unadulterated praise for his predecessor in the introduction to his own text:

> *The general complexion of the treatise differs considerably from that of several excellent electrical works, published, most of them, in Germany, and it may appear that scant justice is done to the speculations of several eminent electricians and mathematicians. One reason of this is that before I began the study of electricity I resolved to read no mathematics on the subject till I had first read through Faraday's* Experimental Researches in Electricity. *I was aware that there was supposed to be a difference between Faraday's way of conceiving phenomena and that of the mathematicians, so that neither he nor they were satisfied with each other's language. I had also the conviction that this discrepancy did not arise from either party being wrong. I was first convinced of this by Sir William Thomson, to whose advice and assistance, as well as to his published papers, I owe most of what I have learned on the subject.*
>
> *As I proceeded with the study of Faraday, I perceived that his method of conceiving the phenomena was also a mathematical one, though not exhibited in the conventional form of mathematical symbols. I also found that these methods were capable of being expressed in the ordinary mathematical forms, and thus compared with those of the professed mathematicians.*
>
> *For instance, Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centres of force attracting at a distance: Faraday saw a medium where they saw nothing but distance: Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids.*
>
> *When I had translated what I considered to be Faraday's ideas into a mathematical form, I found that in general the results of the two methods coincided, so that the same phenomena were accounted for, and the same laws of action deduced by both methods, but that Faraday's methods resembled those in which we begin with the whole and arrive at the parts by analysis, while the ordinary mathematical methods were founding on the principle of beginning with the parts and building up the whole by synthesis.*
>
> *I also found that several of the most fertile methods of research discovered by the mathematicians could be expressed much better in terms of ideas derived from Faraday than in their original form.*
>
> *The whole theory, for instance, of the potential, considered as a quantity which satisfies a certain*

> *partial differential equation, belongs essentially to the method which I have called that of Faraday. According to the other method, the potential, if it is to be considered at all, must be regarded as the result of a summation of the electrified particles divided each by its distance from a given point. Hence many of the mathematical discoveries of Laplace, Poisson, Green and Gauss find their proper place in this treatise, and their appropriate expressions in terms of conceptions mainly derived from Faraday.*
>
> …
>
> *I have confined myself almost entirely to the mathematical treatment of the subject, but I would recommend the student, after he has learned, experimentally if possible, what are the phenomena to be observed, to read carefully Faraday's* Experimental Researches in Electricity. *He will there find a strictly contemporary historical account of some of the greatest electrical discoveries and investigations, carried on in an order and succession which could hardly have been improved if the results had been known from the first, and expressed in the language of a man who devoted much of his attention to the methods of accurately describing scientific operations and their results.*
>
> *It is of great advantage to the student of any subject to read the original memoirs on that subject, for science is always most completely assimilated when it is in the nascent state, and in the case of Faraday's* Researches *this is comparatively easy, as they are published in a separate form, and may be read consecutively. If by anything I have here written I may assist any student in understanding Faraday's modes of thought and expression, I shall regard it as the accomplishment of one of my principal aims — to communicate to others the same delight which I have found myself in reading Faraday's* Researches.

There are a lot of interesting ideas in this passage, first and most obvious among them the admiration that Maxwell had for Faraday's work. (It's worth noting that Faraday had been dead for several years by the publication of Maxwell's book, so he wasn't just attempting to placate a powerful colleague.)

Maxwell concisely summarizes one of the reasons that I find the study of the history of science useful: "science is always most completely assimilated when it is in the nascent state." This reminds me of a discussion I had once as a T.A. for a math methods class: the teacher was "old school", and the recommended texts for the course were all classics of mathematical literature. Some students actually complained to me about being forced to read "old books!" My immediate response was something to the effect of: "If you're planning to do research, you're going to have to read an old reference eventually, you might as well learn to do it now!" There's an even more compelling reason to read from the original sources: the discoverers of a phenomena or theorem are almost always the ones who understood it best, as they likely spent the most time thinking about the problem.

It is also interesting to note that Maxwell decided, in his own researches, to focus first and foremost on the experimental results of Faraday, and not the mathematical speculation of the time. This is a wise application of the general idea that experiment is the ultimate authority in physics. I still strongly believe this, and constantly emphasize it, even though I'm a theorist myself!

For the mathematically-minded, I should note that I came across Maxwell's book when I was doing some research on Green's functions. It turns out that the collected mathematical papers of George Green can be read on Google books; these papers include "An essay on the application of mathematical analysis to the theories of electricity and magnetism" (1828), which first not only introduced the important theorem of vector calculus which would eventually become known as Green's theorem and the idea of what would be called Green's functions, but also introduced the term "potential" to describe the action of a collection of masses/charges at a given point in space.

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## 3 Responses to *Maxwell on Faraday*

**Blake Stacey** *says:*
July 26, 2009 at 12:01 pm

> *Faraday saw a medium where they saw nothing but distance:*

Dang, that's a nice turn of phrase.

Reply

**Peter Lund** *says:*
August 5, 2009 at 8:54 pm

Phenomenon in the singular.

Reply

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