Fields of influence

Paul M. Grant

Driving Force: The Natural Magic of Magnets. By James D. Livingston. *Harvard University Press: 1996. Pp. 311. $24.95, £15.95.*

> A wonder of such nature I experienced as a child of 4 or 5 years, when my father showed me a compass. That this needle behaved in such a determined way did not at all fit into the nature of events which could find a place in the unconscious world of concepts (effects connected with "direct" touch). I can still remember — or at least believe I can remember — that this experience made a deep and lasting impression upon me. Something deeply hidden had to be behind things.

WITH this excerpt from Albert Einstein's biography, James Livingston, formerly a staff member at General Electric's Corporate Research and Development Center and now a senior lecturer at the Massachusetts Institute of Technology (MIT), opens his delightful little book. Although not all Einsteins, most five-year-olds are nonetheless remarkably inquisitive. I am fortunate to have one at home, my son Diego Patrick, who has recently carried out his own 'experiments' on bar magnets. For him, the repulsive aspect of magnetism is far more intriguing than attraction, and his attempts to defeat Earnshaw's theorem — which states that an object cannot be stably suspended in space by permanent magnets alone — while erratically chasing one magnet with the other are fascinating to watch. I am sure most of us, as Livingston points out was true for him as well as Einstein, have had Diego's experience as part of our childhood introduction to science. Five is about the right age for beginning to marvel and reflect on 'force-at-a-distance', a phenomenon mysterious and beautiful still to us mature physicists — well, to this one certainly.

Driving Force is, in a sense, two books in one. The author attempts to integrate a sociologically oriented exposition of magnetism with an elementary introduction to its science, an interesting and generally exceptional approach, pioneered some years ago by the popular liberal arts college textbook *Physics for Poets* by Robert March (4th edn, McGraw Hill, 1996) How successful he is depends, I think, on the background of the reader. Personally, I find the lecture-form digressions into technical details distracting, but then, as a practising solid-state physicist, I've already been there. On the other hand, I consider myself a serious lay student of the history and culture of both science and pseudoscience, and it was this side of the book that kept me up late at night. Livingston treats it with a winning combination of dry humour, wit and cheekiness, occasionally spiced with mildly bawdy allusions. It must be a lot of fun to take one of his courses at MIT. (To the best of my knowledge, I have not yet met the author personally, but I am acquainted with some of his former colleagues at General Electric whose stories about him are clearly reflected in his writing style.)

The tone of the book is immediately conveyed by the chapter titles in the table of contents: "Romancing the Stones", "Magnus Magnes", "Thanks for the Memories", "Source of the Force" — all connect magnetism to both past and present human culture and its underlying technology. This connection ranges over an incredible breadth of topics and personalities, a few (nonscientist) examples of the latter being James Bond, Plato, Ben Jonson, Gilbert and Sullivan, the other William Gilbert (Queen Elizabeth's magnetic physician, a scientist of course), Jonathan Swift, Mary Baker Eddy, Dick Tracy, Uri Geller and Madonna. In addition to a review of the usual and expected applications of magnetism, one finds such exotica as cat doors, continental drift, bird migration, a marvellous variety of magnetic toys, Giambattista della Porta's fantasy telegraph, the non-effect of low-frequency magnetic fields in inducing cancer, magnets and magicians, and magnetism in medicine (some sheer quackery and others developments with great promise, such as magnetocardiography and magnetoencephalography).

Topically, *Driving Force* is pretty much as up to date as could be expected on the technical side, including a discussion of giant magneto-resistance and high-temperature superconductivity, and most important historical developments are more than adequately covered. But having been 'present at the creation', I would have liked to have seen more than one paragraph given to the development of magnetic core memories and their enormous influence on the development of digital computers. Also, I looked in vain for clarification of the famous legend that Hans Christian Oersted indeed discovered the existence of electromagnetism while delivering a public lecture. Then again, I enjoyed vicariously re-experiencing the no-holds-barred conflict between Edison on one side and Tesla and Westinghouse on the other over the respective merits of direct versus alternating current in the early days of the electricity industry. Supporters of Edison coined the term 'westinghoused' to describe electrocution by alternating current, surely cause for a defamation-of-character lawsuit in today's litigious society. But with high-temperature superconductors and cryosilicon-controlled rectifiers, Edison might just win in the

"The magnet and the churn" illustrating a song about unrequited magnetic attraction from Gilbert and Sullivan's comic opera *Patience* (1881). Illustration attributed to William Gilbert.

ROBOTMAN by Jim Meddick

long run, as low-voltage direct-current transmission and distribution take over in emerging industrial regions globally. Here, however, Livingston makes a cogent observation on materials and technologies in general: "a better figure of merit than energy product is *energy product per dollar*". Harvard, he says, did not teach him this as a graduate student, and nor did it me during my time at that illustrious institution. It is still probably the case.

My few criticisms aside, this is a smashing book. I wish I had written it and I want to write one like it some day. I wish something similar had been around when I was in high school. In an era of unfortunate public distrust and misunderstanding of the scientific method, I wish there were more science books for the general population written with so engaging an approach. Finally, in the spirit in which the author began his book, and I this review, I wish the 'natural magic of magnets' was used more often to introduce science to children in our pre-schools. It isn't, not in my neck of the woods, and it's a shame. As the Yanks say, "There oughta be a law...". □

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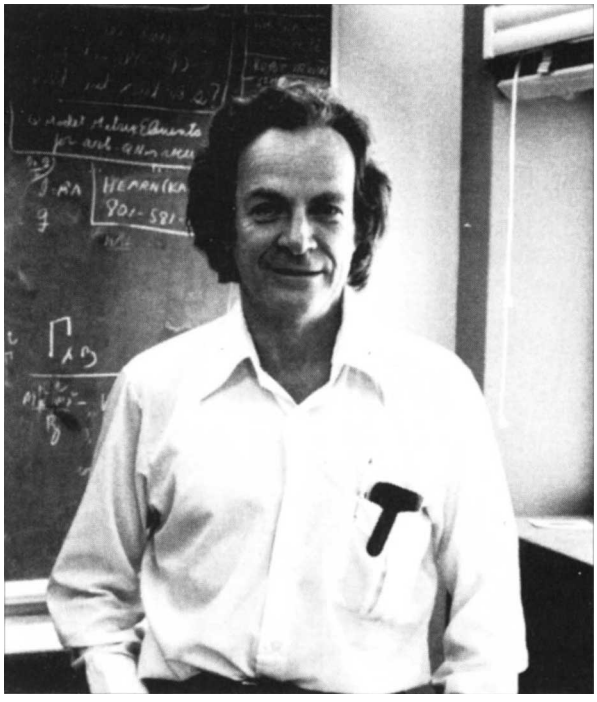
Changing music of the spheres

Paul Murdin

Feynman's Lost Lecture: The Motion of Planets Around the Sun. By David L. Goodstein and Judith R. Goodstein. *Norton: 1996. Pp. 224. $35, £16.99. To be published in the UK by Jonathan Cape in July.*

RICHARD Feynman, renowned for his sophisticated course of physics lectures at the California Institute of Technology in the early 1960s, also gave guest lectures. Records of only five of them survive. "The Motion of the Planets Around the Sun", the only publishable one, was discovered by Judith Goodstein, the archivist at Caltech, and has now been released on compact disc with notes edited by the physicist David Goodstein.

The theme of the lecture is Kepler's first law (1609), which states that the orbits of the planets are conic sections or ellipses. In 1684, Isaac Newton explained to Edmund Halley that simple principles in dynamics and a central inverse-square force were sufficient to give planetary orbits as described by Kepler's three empirical laws, including his second (the radius-vector from the Sun to a planet sweeps out equal areas in equal times) and his third (the 'harmonic law' — the period of a planet is proportional to the three-halves power of its mean distance from the Sun). The second law represents the conservation of angular momentum, the third law comes from the inverse-square law and the first law follows from the other two.



Feynman's argument will be accessible to any science student from sixth-form level upwards.

Newton's explanation is a virtuoso piece to perform. Like a musical performance transcribed for modern instruments, Feynman's is, however, not quite a repeat of the original tune, and it has an original cadenza, placed, unusually, at the end.

In *Principia Mathematica* (1687), Newton relied heavily on the properties of conic sections. Feynman follows Newton's geometric methods but uses nothing more advanced than congruent triangles. At first he follows Newton exactly, but then he diverges. "I found I couldn't follow [Newton's proof] very well, because it involves so many properties of conic sections. So I cooked up another one", he says. Feynman's cooking, presumably independently, follows a recipe published by James Clerk Maxwell, who in turn attributed it to Sir William Hamilton.

Feynman's Lost Lecture goes over some well-trodden history, from Copernicus through Newton to Einstein, and contains reminiscences about Feynman, including the rediscovery of the lecture. There is a transcript of the lecture itself, as well as a compact-disc recording of Feynman delivering it to the Caltech freshman class of 1964. The core of the book is a step-by-step account of his argument that will be accessible to any science student, from sixth-form (high-school) level upwards.

The closing minutes of the lecture display Feynman's gift for lateral thinking. Apparently with time to spare, Feynman turns to Rutherford's experiment demonstrating the small size of the atomic nucleus by alpha-particle scattering. This is a problem of electrostatic repulsion, not of gravity, but the force is a centrally acting inverse-square law and the alpha particles have Keplerian motion. All the Newtonian arguments apply. With them, Feynman derives the probability of the deflection angle of an alpha particle. He uses a treatment by U. and L. Fano from a basic atomic physics textbook of 1959; this seems to have been what gave Feynman the idea of this enjoyable lecture in the first place. □

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A honeyed society

Ross H. Crozier

The Wisdom of the Hive: The Social Physiology of Honey Bee Colonies. By Thomas D. Seeley. *Harvard University Press: 1996. Pp. 295. $49.95, £31.50.*

> *That which is not good for the swarm, neither is it good for the bee.*
> Marcus Aurelius

EDWARD O. Wilson, commenting on the work of Karl von Frisch, once wrote that the honeybee is like a magic well to which one can always return for something new and refreshing in the study of social behaviour. The species repays its acolytes by providing all sorts of avenues of investigation not only into selection of a eusocial species (and an economically important and semi-domesticated one at that), but also into the social integration of many individuals to form a smoothly functioning whole. Thomas Seeley stresses the second aspect, providing a largely personal