Vignette: Asocial Behavior

Henry Cavendish, the notable physicist and chemist, illustrates how schizothymic a creative genius can be. Once, when he was coerced into attending a formal occasion, he found himself about to be introduced to some scientific celebrities from the Continent. Rather than endure the social chit-chat, Cavendish abandoned all amenities, turned away from his escorts, and sped down the hall, squealing like a bat. . . .

Admittedly, Cavendish went off the deep end on this trait. Even so, other notables, scientific and artistic, are more likely to avoid the entertainments of society than to seek them out. . . . So preoccupied and dedicated must be the creative intellect that even the home hearth must not expect the attentiveness customarily due family life. Once when Karl Gauss was enthralled with a mathematical problem, a servant came in to advise him that his wife, who was quite ill, was about to breathe her last. He could only mutter, "Tell her to wait a moment till I'm through." Gauss was clearly deficient in Guilt Proneness and Group Superego as well!

—*Dean Keith Simonton*, in *Greatness: Who Makes History and Why* (Guilford Press)

repeat offenders, they may recall Dan Quayle's version, "A mind is a terrible thing to lose." The equations of MHD have a beguiling beauty and their solutions a captivating complexity. There is little doubt that they determine the answers to many of the central questions of astrophysics: how do stars form, why do pulsars shine, how do quasars shine? So why is it that so few astronomers encourage such research and so many might support the creation of a Betty Ford clinic for habitual abusers of helicity and the induction equation?

Like most phobias, the astronomical community's magnetophobia arises in part from an irrational fear of the unknown and in part from dimly remembered historical events. Successful theories of astrophysical phenomena with few observational diagnostics have been simple (for example, the internal structure of nonrotating stars in hydrostatic equilibrium). Complicated theories (for example, of radiative transfer) can only be validated in applications where there are many observational diagnostics (as in stellar atmospheres or the interstellar medium). There are painfully few quantitative diagnostics of cosmic magnetic fields. Yet the theory of the fields inevitably involves the nonlinear dynamics and topology of a tensor field in which events occuring over a 10-order-of-magnitude range of scales are vitally interconnected. This unfortunate combination is the historical basis for magnetophobia.

The collection of reviews in *Cosmical Magnetism* should help dispel, or at least make rational, the magnetophobia of research students and senior colleagues interested in self-improvement. The 18 short (14 pages or less) reviews, by pundits of the field, quickly lay out the state of the art and the current frontiers. Beginners should start with the first and the last of the chapters. The first, by Keith Moffatt, gives a characteristically lucid introduction to dynamo theory and its application to the simplest and best-diagnosed cosmic source of magnetism: the Earth. Its simplicity arises because the magnetic Reynolds number is low, though the fluid convection may have a high Reynolds number. Historical and fossil records of the Earth's surface magnetic field, plus Laplace's equation for the magnetic potential, allow the distribution of radial magnetic field at the Earth's core-mantle boundary to be determined over millions of years. This recently reconstructed "movie" is a valuable and suggestive test of dynamo models.

The last chapter, the longest and widest-ranging, is in many ways the most profound. This is not unexpected, for it is by Leon Mestel. The book commemorates a workshop held in honor of his seminal contributions to modern astrophysics. With his distinctive precision of thought, he examines the effects of magnetic fields on stellar rotation (on short and long time scales), dispels myths about the relation of magnetic fields to star formation, reviews Galactic dynamos and proposes an ingenious new one, discusses the magnetospheres of pulsars (the rotating magnetized neutron stars now responsible for two sets of Nobel prizes), and concludes with a discussion of magnetic energy extraction from black holes—a promising source of energy for quasars luminous in radio and gamma-rays.

Between these two chapters are others that elaborate on the subjects covered by Mestel: magnetic A-stars (Meyer), star formation (Zweibel), magnetic winds (Spruit), pulsar magnetospheres (Kahn and da Costa), active galaxies (Blandford). Five chapters cover Galactic dynamos, both observation (Davies, Wielebinski) and theory (Parker, Rees, Krause). Two chapters on the heating of the solar corona (Priest *et al.*, Heyvaerts) discuss a field in which the terrifying detail of recent observations may lead to magnetophobia of a different sort. There is a nice summary of the properties of magnetic white dwarfs (Landstreet), whose wide distribution of field strengths and rotation periods poses an outstanding puzzle. None of the reviews are comprehensive enough to equip a novice reader for research. And some are as thoroughly recycled as aluminum. But the prose and intellectual content are of the highest order, and the brevity of the reviews makes them seductive reads. The book will attract young competitors for Mestel, who is now, as he puts it, doing "what one enjoys doing without suffering the distractions inevitable during the payroll years." The beauty and importance of cosmic magnetism deserve more attention from equally great minds.

The book of non-review papers presented at the same workshop is published as *Cosmical Magnetism: Contributed Papers* by the Institute of Astronomy, Cambridge CB3 OHA, England (attn: Mrs. S. Bridgeman) at $15 or £7.50.

E. S. Phinney
Theoretical Astrophysics, California Institute of Technology, Pasadena, CA 91125, USA

■

Tales of Topology

The Knot Book. An Elementary Introduction to the Mathematical Theory of Knots. COLIN C. ADAMS. Freeman, New York, 1994. xiv, 306 pp., illus. $32.95.

The Knot Book by Colin C. Adams is not the only book with this title. There is also *The Knot Book* by Geoffrey Budsworth (Sterling, 1985), a compendium on practical knots by the honorable secretary of the International Guild of Knot Tyers. Budsworth's book is part of a literature on the art of forming knots and weaves whose most famous representative in book form must be *The Ashley Book of Knots* by C. Ashley (Doubleday, 1944). Books for those interested in tying knots and weaves must meet the formidable standards of *The Ashley Book*. Such a book must be visually interesting and able to compress instructions for the generation of complex objects into

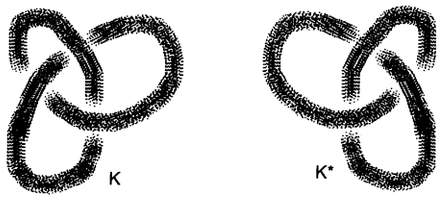
compact and readable form. There should be a good tale or two in the bargain.

Adams's book is a mathematical book on knots that meets these requirements and more. The structure of the book is visually captivating. The reader will learn not only how to tie a few knots but also to appreciate the problems of enumeration and classification that concern the mathematician and theorist of knots. The first 146 pages of the book involve no mathematical background other than an interest in geometrical ideas. These pages take the reader from the simplest ideas of knotting and the elements of topological thinking to matters of coloring, tabulation, tangles, spanning surfaces, hyperbolic structures, and special types of knots. The rest of the book uses nothing more sophisticated than the concept of a polynomial and goes a long way into knot theory and its relationships with natural science.

Knots are a traditional subject for sailors, climbers, practical folk, and magicians. It is only since the late 1860s or thereabouts that the subject has been taken up by mathematicians. In 1869 Lord Kelvin put forth the theory that atoms of matter were knotted vortex tubes of ether. His theory promised to explain the observed stability and variety of the atoms on geometrical grounds. The vibrations of the vortex tubes would explain the spectra of the atoms. Kelvin enlisted the mathematicians Kirkwood, Little, and Tait in the task of enumerating the possible shapes of these vortices. In this enumeration the mathematical theory of knots was born.

After the emergence of the Michelson-Morley experiment and Albert Einstein's theory of special relativity, the ether and with it Kelvin's theory of the vortex atoms disappeared. The theory of knots, however, did not die. It flourished and became one of the great sources for the rapidly developing mathematical subject of topology—the study of properties of spaces preserved under continuous deformation. The idea of linkages between knots and physics did not die either, but underwent many transformations and a remarkable resurgence beginning in 1984, the year of the discovery of the Jones polynomial. (See M. F. Atiyah, *The Geometry and Physics of Knots* [Cambridge University Press, 1990] and L. H. Kauffman, *Knots and Physics* [World Scientific, 1991 and 1993].)

A knotted vortex, like a smoke ring, forms a closed loop in three-dimensional space. The knots studied by mathematicians have nearly always been in the closed-loop form. This form is preferable for looking at topological properties, since the knot cannot just slip off the end of the rope if the rope has no end. Tie a knot in a length of rope. Splice the ends together. You now have a handsome and topologically durable representative of that knot. Two knots in closed loop form are said to be equivalent if one can be deformed into the other by stretching and twisting the loop. Tearing is not allowed. An example of this phenomenon is the trefoil knot K and its mirror image K*, shown below:



These are both knotted (inequivalent to a flat loop), and they are not equivalent to each other. A knot that is inequivalent to

its mirror image is said to be *chiral*.

Starting in chapter 6, *The Knot Book* introduces the Jones polynomial through an elementary construction (due to this reviewer) called the bracket polynomial. The bracket polynomial is based on the simplest properties of knot and link (more than one loop) projections, and it explicitly embodies the relationships between statistical mechanics and knot theory that have pervaded the subject ever since Jones made his discovery. With a little work, the reader will go from being a naive knot topologist on page 147 to being equipped to prove the chirality of the trefoil on page 155. This is the watershed. It is the fond hope of this reviewer that every reader of *The Knot Book* will work through these critical eight pages of the text.

The book continues with material on the new invariants of knots and links and on applications to alternating knots. Chapter 7 details applications to knots in biology (DNA), chemistry, and physics. Later chapters discuss graphs, statistical mechanics, three-dimensional topology, and knots in higher dimensions.

Adams's *Knot Book* is a terrific addition to the assemblage of books on knots. It deserves to be on the shelf of every natural scientist, sailor, climber, magician, and mathematician.

Louis H. Kauffman
Department of Mathematics, Statistics and Computer Science, University of Illinois, Chicago, IL 60607–7045, USA

■

Books Received

All God's Mistakes. Genetic Counseling in a Pediatric Hospital. Charles L. Bosk. University of Chicago Press, Chicago, 1992. xxvi, 195 pp. $24.95.

The American Museum of Natural History's Book of Dinosaurs and Other Ancient Creatures. Joseph Wallace. Simon and Schuster, New York, 1994. 144 pp., illus. $25.

The Application of Economic Techniques in Environmental Impact Assessment. David James. Kluwer, Norwell, MA, 1994. xvi, 298 pp., illus. $110 or £76 or Dfl. 195. Environment and Management, vol. 4.

The Biosynthesis of the Tetrapyrrole Pigments. Derek J. Chadwick and Kate Ackrill, Eds. Wiley, New York, 1994. xvi, 350 pp., illus. $76. Ciba Foundation Symposium, vol. 100. From a symposium, London, April 1993.

Cerebrospinal Fluid in Neurology and Psychiatry. H. McConnell and J. Bianchine, Eds. Chapman and Hall Medical, New York, 1994. xiv, 322 pp., illus. $69.95.

Chemical Methods in Prokaryotic Systematics. Michael Goodfellow and Anthony G. O'Donnell, Eds. Wiley, New York, 1994. xxvi, 576 pp., illus. $129.95. Modern Microbiological Methods.

Electrical Safety. A Guide to the Causes and Prevention of Electrical Hazards. J. Maxwell Adams. Institution of Electrical Engineers, Stevenage, Herts, U.K., 1994. viii, 194 pp., illus. $75. IEE Power Series, 19.

Engineering Design. A Synthesis of Views. Clive L. Dym. Cambridge University Press, New York, 1994. xviii, 205 pp., illus. $49.95; paper, $19.95.

Gypsies and Travelers in North America. An Annotated Bibliography. William G. Lockwood and Sheila Salo. Gypsy Lore Society, Cheverly, MD, 1994. iv, 196 pp. Paper, $20. Gypsy Lore Society Publication no. 6.

International Stratigraphic Guide. A Guide to Stratigraphic Classification, Terminology, and Procedure. Amos Salvador, Ed. 2nd ed. International Union of Geological Sciences, Trondheim, Norway, and Geological Society of America, Boulder, CO, 1994. xx, 214 pp., illus. $48.50.

Molecular Mechanisms in Bioenergetics. Lars Ernster, Ed. Elsevier, New York, 1994. xx, 521 pp., illus. Paper, $91.50 or Dfl. 160. New Comprehensive Biochemistry, vol. 23. Reprint 1992 ed.

Multistage Selection and Ranking Procedures. Second-Order Asymptotics. Nitis Mukhopadhyay and Tumulesh K. S. Solanky. Dekker, New York, 1994. xvi, 405 pp. $125. Statistics: Textbooks and Monographs, vol. 142.

Possessing Nature. Museums, Collecting, and Scientific Culture in Early Modern Italy. Paula Findlen. University of California Press, Berkeley, 1994. xviii, 449 pp., illus. $55. Studies on the History of Society and Culture, 20.

Steroid Contraceptives and Women's Response. Regional Variability in Side-Effects and Pharmacokinetics. Rachel Snow and Peter Hall, Eds. Plenum, New York, 1994. x, 266 pp., illus. $85. Reproductive Biology. From a symposium, Exeter, NH, Oct. 1990.