Book Reviews

Astrophysical Discontinuities

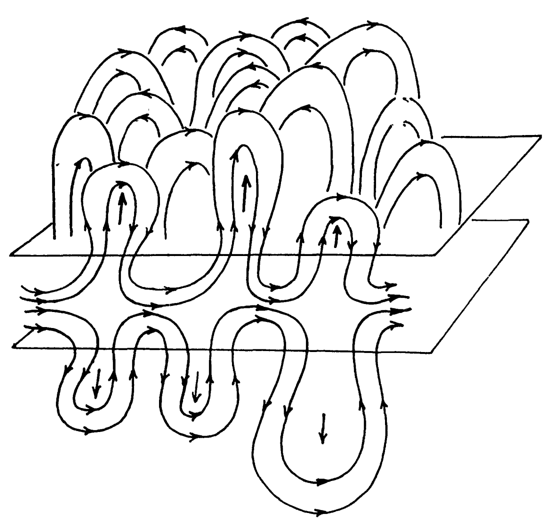
Spontaneous Current Sheets in Magnetic Fields. With Applications to Stellar X-rays. EUGENE N. PARKER. Oxford University Press, New York, 1994. xiv, 420 pp., illus. $85 or £65. International Series on Astronomy and Astrophysics, 1.

Let Eugene Parker introduce the subject of his book: "The basic theorem of magnetostatics asserts that the Maxwell stresses in all but the simplest field topologies continually strive to produce current sheets of vanishing thickness and unbounded current density, i.e., surfaces of tangential discontinuity in the magnetic field" (p. 367). Dry words, perhaps, to the nonspecialist in magnetohydrodynamics, but it is difficult to think of a concept that has had more impact on current ideas in solar physics, or an astrophysical topic (apart from cosmology) that has drawn contributions from a more diverse group of scientists, including laboratory plasma physicists, mathematicians, and fluid dynamicists, as well as solar physicists. In *Spontaneous Current Sheets in Magnetic Fields* Parker has written down his vision of the history, the state of the art, and the future of this field.

First, some background. By the early 1940s it was established that the sun's extended outer atmosphere, or corona, has a kinetic temperature of more than 10^6 K, some 200 times larger than the temperature of the visible solar disk. Therefore it could not be radiatively heated; but without a heating mechanism it would cool and collapse in several hours. By the end of the decade Biermann, Schwarzschild, and others had suggested that the corona is heated by the dissipation of mechanical energy at the top of the convection zone, the turbulent layer just below the visible disk. The first theories of this energy transfer centered on the generation of upward-traveling waves by the convection and their subsequent damping.

By the 1970s the advent of x-ray imaging detectors and advances in magnetic field mapping had shown that the hottest and densest coronal plasma is associated with arch-like configurations, or loops of magnetic field. The distinctive spectroscopic signatures of coronal plasma were detected on other stars thought to have surface convection zones. Solar- and stellar-flare research was developing in parallel and pointing toward the idea that a flare is initiated by the rapid release of stored magnetic energy, and that this energy release can be large but is more probably small: The frequency of flares as a function of flare energy is a power law over several decades. Theorists made simple models of static magnetic arches, studied wave propagation within them, and applied linear stability theory to predict the rapid release of energy.

Parker's fundamental contribution was to suggest that these static equilibrium models can be realized in nature only under extraordinarily special conditions. He presented instead a picture of the coronal magnetic field with topology locked in by virtue of being rooted in the dense gas at the coronal base, ceaselessly stirred by the convective motions in that gas, and forced, because its energy density is so large compared to that of the tenuous coronal plasma, to come rapidly into local force balance, or equilibrium. And he suggested that, in the generic case, there is no smooth equilibrium accessible and that the magnetic field adjusts by being smooth almost everywhere but discontinuous on certain surfaces, called current sheets. The magnetic shear at these current sheets is so strong that magnetic energy is rapidly dissipated there, providing the basic mechanism for heating magnetic loops.



"A schematic drawing of the close packed lobes of magnetic field inflated outward from both sides of the gaseous disk of the Galaxy to create the galactic halo." [From *Spontaneous Current Sheets in Magnetic Fields*]

Parker's idea was met with great interest and some skepticism. Its connection with problems of vortex singularity formation in fluid dynamics drew the attention of fluid dynamicists. Parker and others were able to provide explicit examples of current-sheet formation based on analytical calculations, but their genericity has gone unproven. Computational plasma physicists began to use numerical codes, some developed for the controlled fusion program, to investigate singularity formation. It was shown that random motions of the field-line foot points build structure into the field on increasingly small scales, providing an alternative means for reaching the dissipation length scale. Theorists pondered the connection, if any, between linear instability and the onset of current-sheet formation. And some solar physicists attempted to assess the efficiency of the mechanism for coronal heating and to find observationally testable consequences of it, while others worried that the problem as posed made too many idealizations about the solar atmosphere to be relevant.

The first 10 chapters of the book deal primarily with the theoretical ideas. The two main themes are the formation of singularities and the nature of dissipation in singularities once they form, also called the theory of magnetic reconnection (Parker has made fundamental contributions to the latter topic, also). The 11th and 12th chapters apply these ideas to solar and stellar physics and point out their importance in systems ranging from the terrestrial magnetosphere to the galactic halo. The second chapter of the book is a marvelously concise introduction to plasma physics and magnetohydrodynamics that makes the book virtually self-contained and readable by anyone with a background in applied differential equations at the level attained by most physicists. Such a background is necessary in order to work through many of the numerical examples, but no one who is interested in the subject should put this book aside because of the large amount of formal material—Parker has great gifts for physical explanation and for expository writing, and he makes the ideas accessible without detailed study of the mathematical examples. For those who do want to delve into the mathematics, the ideas and calculations found in many of his papers over more than two decades are contained succinctly in the book.

Spontaneous Current Sheets in Magnetic Fields is a major work that should be read by anyone interested in magnetohydrodynamics or plasma astrophysics. It will be an influential book for a long time to come.

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Courtly Naturalism

Possessing Nature. Museums, Collecting, and Scientific Culture in Early Modern Italy. PAULA FINDLEN. University of California Press, Berkeley, 1994. xviii, 449 pp., illus. $55 or £42. Studies on the History of Society and Culture, 20.

Paula Findlen's study contributes in important new ways to our understanding of science in the 16th and 17th centuries, the period of the "Scientific Revolution." The development of physics and mechanics in the period has received most of the attention from historians of science in the last 40 years. Findlen's book is one of several that have recently taken up other aspects of early modern science. By exploring two related developments in Italy during these two centuries—the foundation of museums and the establishment of natural history as a discipline—Findlen is able to shed light on the growth of scientific culture in Europe. Focusing on the ideas and practices of Ulisse Aldrovandi (1522–1605) and Athanasius Kircher (1602–1680), but including accounts of many other naturalists resident in Italy during the period, Findlen explores the attitudes of the time toward "collecting and the interrogation of nature." She looks at the new naturalism in both its relationship to changing Aristotelian ideas and its dependence on Renaissance courtly culture. She is interested in the audience for the new natural science as much as in its most illustrious practitioners, in how and where it was practiced as much as in why.

Experiments with asbestos as depicted in Ferrante Imperato's *Dell'historia naturale* (Naples, 1599). "Imperato was instrumental in establishing an experimental culture that moved away from the humanist view of knowledge as a textual entity and toward a more artifactual understanding of nature. . . . Physicians such as Bartolomeo Maranta and the Lincean Nicola Antonio Stelliola collaborated closely with Imperato in their research on theriac and other medicines. . . . The experiences that occurred within Imperato's museum were not dissimilar to those in Aldrovandi's *studio*, although Imperato more often personally demonstrated artifacts for his visitiors whose social status, as physicians, was higher than his own." [From *Possessing Nature*]

Ulisse Aldrovandi as depicted in his *Ornithologiae hoc est de avibus historiae libri XII* (Bologna, 1599). A legend accompanying the portrait reads, "Non tua, Aristoteles, haec est, sed Ulyssis imago: Dissimules vultus, par tamen ingenium." [From *Possessing Nature*]

Findlen's study develops a number of important arguments. First and foremost is that the contemporary culture of the Italian courts is a key to explaining the development of the new science. Museums and natural history emerged from humanists' emphasis on sociability as much as from their interest in exploring (and, soon, in correcting) ancient literature. Without the courtly audience for the new learning, the naturalists would not have found patrons for their endeavors or markets for their books. In light of the importance Findlen attaches to courtly culture in this regard, she examines the ways in which values such as memory, civility, and curiosity shaped the new science, and she does so impressively. In the concluding chapters, she even makes much of the ways in which the new and protean possibilities of exploring the self could be mirrored through exploring nature. Second, Findlen finds the major shift in attitudes toward nature occurring among some groups just after the beginning of the 17th century, when the private *studio* became the public *galleria* and when the relation of authority between experience and ancient texts reversed itself, so that where once the credibility of experience was derived from the authority of the texts experience came to be seen as a guide to their interpretation. Not everyone adopted these changed attitudes immediately, however, so Findlen has many telling remarks about the differences between proponents of the new science such as Francesco Redi and exponents of an older view, such as Kircher. And third, in the latter parts of her book, Findlen is clear about the strong relationship between the new naturalism and contemporary medical studies, with their connections to botanical gardens, anatomy theaters, and medicines.

Findlen's concentration on courtly culture may be too strong for some. She has many intelligent things to say about academic traditions, new markets, and the explosion of interest in the new worlds of east and west, but she keeps coming back to courtly life as her explanatory device. Although she is aware that museums and natural history could grow in soil that was not Italian, aristocratic, or courtly, she concludes that "the museum was the quintessential product of the patronage culture of early modern Europe" (p. 346) and that "mastery of nature went hand in hand with the rhetoric of absolutism; museums were an eminently visible reminder of how political might, new forms of knowledge, and power over nature could be combined" (p. 407). Whether this is a general causal explanation or only a fine description of the way things often worked in Italy must be left for others to decide.

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Other Books of Interest

The Aye-Aye. Madagascar's Most Puzzling Primate. ANNA C. FEISTNER and ELEANOR J. STERLING, Eds. Karger, Farmington, CT, 1994. iv, 180 pp., illus. Paper, $78.50 or sFR 98 or DM 117. Folia Primatologica, vol. 62, no. 1–3.

In its native habitat *Daubentonia madagascariensis*, the subject of this work, is, according to the editors, alternately feared, perse-