

## American Association for the Advancement of Science

*Science* serves its readers as a forum for the presentation and discussion of important issues related to the advancement of science, including the presentation of minority or conflicting points of view, rather than by publishing only material on which a consensus has been reached. Accordingly, all articles published in *Science*—including editorials, news and comment, and book reviews—are signed and reflect the individual views of the authors and not official points of view adopted by the AAAS or the institutions with which the authors are affiliated.

**Publisher:** Richard S. Nicholson

**Editor:** Daniel E. Koshland, Jr.

**Deputy Editor:** Ellis Rubinstein

**Managing Editor:** Monica M. Bradford

**International Editor:** Alun Anderson

**Deputy Editors:** Philip H. Abelson (*Engineering and Applied Sciences*); John I. Brauman (*Physical Sciences*); Thomas R. Cech (*Biological Sciences*)

## EDITORIAL STAFF

**Assistant Managing Editor:** Dawn Bennett

**Senior Editors:** Eleanor Butz, Martha Coleman, Barbara Jasny, Katrina L. Kelner, Phillip D. Szuroimi, David F. Voss  
**Associate Editors:** R. Brooks Hanson, Pamela J. Hines, Kelly LaMarco, Linda J. Miller, L. Bryan Ray

**Letters:** Christine Gilbert, *editor*; Steven S. Lapham

**Book Reviews:** Katherine Livingston, *editor*; Teresa Fryberger

**Contributing Editor:** Lawrence I. Grossman

**Chief Production Editor:** Ellen E. Murphy

**Editing Department:** Lois Schmitt, *head*; Denise Gipson, Julianne Hunt, Steven Powell

**Copy Desk:** Joi S. Granger, Margaret E. Gray, MaryBeth Shartle, Beverly Shields

**Production Director:** James Landry

**Production Manager:** Kathleen C. Fishback

**Art Director:** Yolanda M. Rook

**Assistant Art Director:** Julie Cherry

**Graphics and Production:** Holly Bishop, Catherine S. Siskos

**Systems Analyst:** William Carter

## NEWS STAFF

**Managing News Editor:** Colin Norman

**Deputy News Editors:** John M. Benditt, Jean Marx

**News and Comment/Research News:** Ivan Amato, Ann Gibbons, David P. Hamilton, Constance Holden, Richard A. Kerr, Robert N. Langreth, Eliot Marshall, Joseph Palca, Leslie Roberts

**Bureaus:** Marcia Barinaga (West Coast), Michelle Hoffman (Northeast), Anne Simon Moffat (Midwest)

**Contributing Correspondents:** Jeremy Cherfas, Barry A. Cipra, Robert Crease, M. Mitchell Waldrop, Karen Wright

## BUSINESS STAFF

**Marketing Director:** Beth Rosner

**Circulation Director:** Michael Spinella

**Fulfillment Manager:** Marlene Wendell

**Financial Analyst:** Deborah Rivera-Wienhold

**Classified Advertising Supervisor:** Amie Charlene King

## ADVERTISING REPRESENTATIVES

**Director:** Earl J. Scherago

**Traffic Manager:** Donna Rivera

**Traffic Manager (Recruitment):** Gwen Canter

**Advertising Sales Manager:** Richard L. Charles

**Marketing Manager:** Herbert L. Burkland

**Employment Sales Manager:** Edward C. Keller

**Sales:** New York, NY 10036: J. Kevin Henebry, 1515 Broadway (212-730-1050); Scotch Plains, NJ 07076: C. Richard Callis, 12 Unami Lane (201-889-4873); Hoffman Estates, IL 60195: Jack Ryan, 525 W. Higgins Rd. (708-885-8675); San Jose, CA 95112: Bob Brindley, 310 S. 16th St. (408-998-4690); Dorset, VT 05251: Fred W. Dieffenbach, Kent Hill Rd. (802-867-5581); Damascus, MD 20872: Rick Sommer, 11318 Kings Valley Dr. (301-972-9270); U.K., Europe: Nick Jones, +44(0647)52918; Telex 42513; FAX (0647) 52053.

**Information for contributors** appears on pages 35–37 of the 4 January 1991 issue. Editorial correspondence, including requests for permission to reprint and reprint orders, should be sent to 1333 H Street, NW, Washington, DC 20005. Telephone: 202-326-6500. **Advertising correspondence** should be sent to Tenth Floor, 1515 Broadway, New York, NY 10036. Telephone 212-730-1050 or WU Telex 968082 SCHERAGO, or FAX 212-382-3725. **Subscription/Member Benefits Questions:** 202-326-6417. **Science:** 202-326-6500. **Other AAAS Programs:** 202-326-6400.

## Astrophysical Plasmas

Stars, galaxies, and fusion reactors all contain a substance that simultaneously obeys the laws of electromagnetism and fluid dynamics. In 1928, Irving Langmuir named it “plasma” and the recipe is simple: take matter and heat until ionized. The result is a collection of charged particles possessing all of the qualities of a fluid but with added twists and turns caused by electric and magnetic fields. Although the use of plasmas for controlled thermonuclear fusion has received the most scientific attention, plasma physics is an essential part of many astrophysical phenomena. The five articles in this issue of *Science* examine plasmas in astrophysical settings, from the densest stars to the most rarified planetary magnetospheres.

Van Horn describes the state of plasma under extremely high pressure, as might be found in white dwarf stars, neutron stars, the giant planets, or the still hypothetical “brown dwarfs.” The electrons are packed so tightly that the exclusion principle of quantum mechanics, rather than electrical repulsion, keeps them apart. Stars in this condition exhibit unusual properties: the stellar structure, for instance, is almost completely independent of temperature. On the other hand, the cores of white dwarfs and the surfaces of neutron stars can freeze solid if the temperature is low enough. Calculations of heat transfer, nuclear reaction rates, and equations of state of dense plasmas allow the evolution of such bodies to be understood.

Jets of plasma associated with stars and galaxies are among the largest and most energetic objects in the universe. De Young surveys the observational evidence and theoretical understanding of these jets. Instead of the spherical outward flows of ionized gas that all stars emit, stellar jets are highly directional. Extragalactic jets are more vigorous, and they take many shapes and sizes. Although much has been learned, the specific energy sources and mechanisms for stellar and extragalactic jets are still puzzles.

McKee and Draine consider another energetic phenomenon: interstellar shock waves. Stellar winds push the surrounding interstellar medium outward at velocities of ten to hundreds of kilometers per second; supernovae generate shock waves that travel up to about 10,000 kilometers per second. The way these shocks collide with the ambient interstellar medium tells much about the nature of that tenuous plasma. Such shock waves are believed to accelerate the cosmic rays that are observed on Earth. Shock waves have also been observed in molecular clouds, the large clumps of neutral gas in the interstellar medium. In this case, the coupling of even small amounts of ionized gas to the neutral matter by magnetic fields can completely alter the structure of the shock wave.

The sun emits a plasma too, the solar wind, and although of low density, it is highly ionized and hot. Neugebauer describes the properties and acceleration mechanisms of the solar wind plasma. It exists in two states: the quasi-stationary solar wind, which fluctuates over time scales of months, and the transient wind, caused by explosive ejection of plasma from the solar atmosphere. Differences in the properties of these two states have been elucidated by interplanetary space probes, but questions still remain about the processes involved. A picture has emerged over the last decade in which the acceleration of the solar wind is tied closely with the heating of the solar atmosphere.

What happens when the solar wind interacts with the magnetic fields of planets to form magnetospheres? Before direct exploration of the solar system by spacecraft, the concept of a magnetosphere—the region where a planet’s magnetic field dominates the solar wind—was unknown. Hill and Dessler discuss the six planets in the solar system that have well-developed magnetospheres: Mercury, Earth, Jupiter, Saturn, Uranus, and Neptune. A comparative approach to studying the motions of plasma within these magnetospheres may lead to a basic understanding of more remote astrophysical systems.

Because they follow two sets of rules, electromagnetic and hydrodynamic, plasmas display a rich array of phenomena. The degrees of freedom are many and the intricacies can be a source of astonishment. Wherever plasmas are located in the cosmos, their complexity continues to challenge observers and theorists alike.—DAVID VOSS