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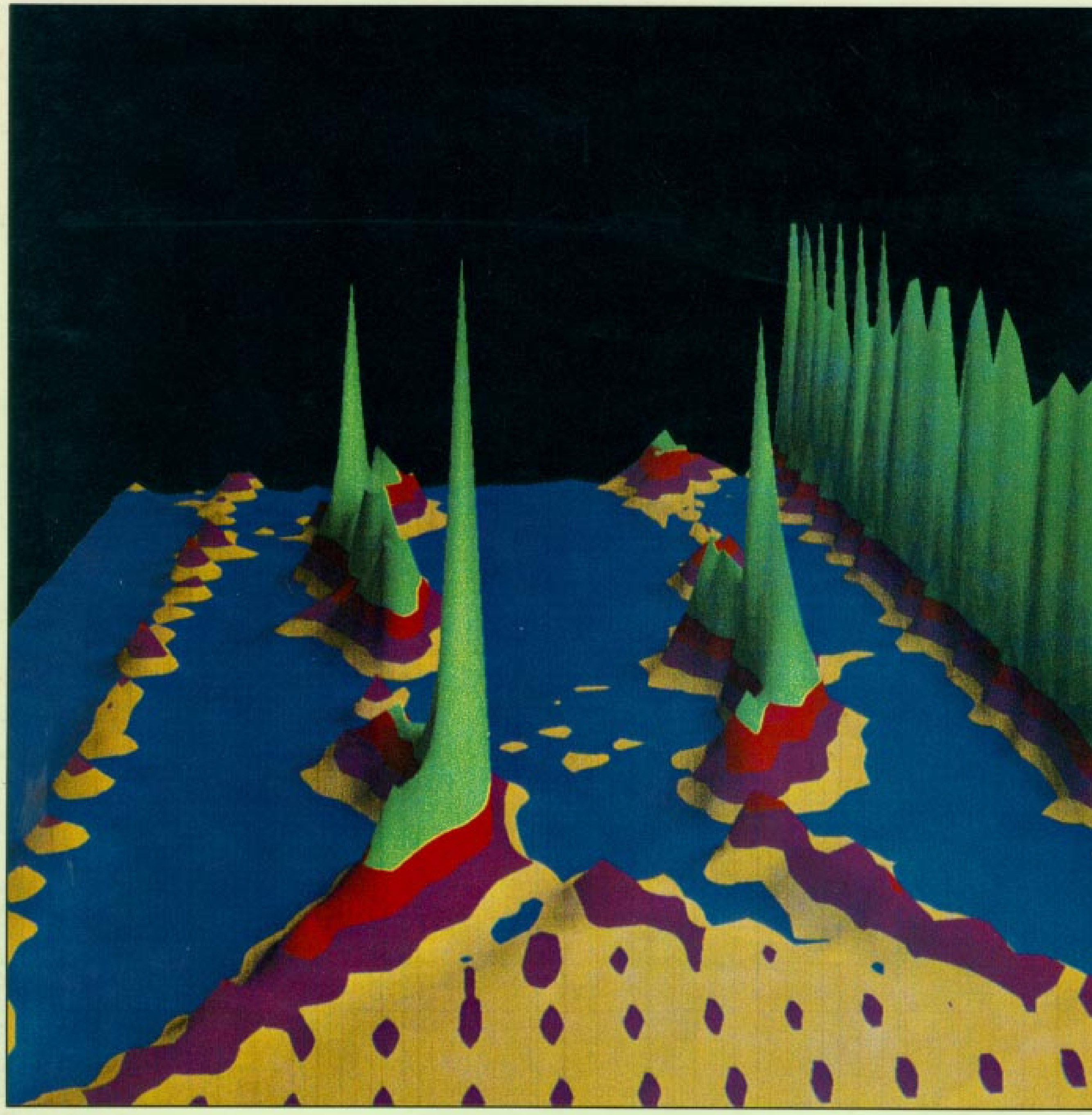
Los Alamos Science

LOS ALAMOS NATIONAL LABORATORY



EDITOR’S NOTE

The issue contains stories of three fascinating and novel explorations: first the exploration of a new idea in bioenergetics that may explain your body’s remarkably efficient use of energy, second the exploration by satellite of the distant reaches of the earth’s magnetosphere, and third, the exploration of surprising behavior in a tiny metallic crystal.

The new idea in bioenergetics involves solitons, an unusual kind of traveling wave. Solitons don’t change their shape and they don't change their speed—even when they run into each other. They continue to pop up in one area of physics after another and now our cover article reports that these pulse-like nonlinear waves may be running around in many parts of our bodies, carrying signals and coordinating processes through membranes and across cells. This novel idea. first proposed ten years ago by the Soviet physicist Davydov, is being explored in this country by Al Scott. chairman of the Center for Nonlinear Studies, along with a number of other people at Los Alamos. In a lucid article Peter Lomdahl, Scott Layne, and Irving Bigio describe specific places in the cell where solitons might be important, outline the mathematical model and numerical results that show how energy can be trapped by proteins and self-focused into stable solitary waves. and, finally. evaluate the experimental evidence supporting the idea. A possible extension of this model. presented by Layne, an M. D., is the idea that anesthetics may work by binding to proteins and thereby interfering with soliton propagation.

Physicists agree that solitons can appear in many different contexts: in ordinary fluids, in plasmas, in lasers, in Josephson junctions, in organic polymers—technical] y speaking in all systems that are nonlinear and dispersive and contain little or no damping. But their existence in biological systems is still quite speculative. Of course speculation can be dangerous. but even if the Davydov model is wrong, this work still represents the beginning of a new approach to understanding macromolecules. an approach that invokes nonlinear dynamics to bridge the gap between structure and function.

The ISEE-3 spacecraft has completed its work collecting data in the earth’s magnetic tail. a long tail of tenuous plasma much like the tail of a comet. The data collected during repeated crossings of the tail at distances from 400.000 to 1,500,000 kilometers from the earth have provided a remarkably detailed picture of the interaction between the solar wind and the magnetosphere, which serves as the earth’s magnetic shield. After months of careful analysis. Jack Gosling, Dan Baker, and Ed Hones are able to show us the fascinating way in which ISEE-3 data demonstrate the existence of an open magnetosphere, one that is constantly being infused with plasma from the solar wind. Of course at some point plasma must also be ejected, and again the data clearly demonstrate how. The authors’ comparison of ground data. data from a near earth orbit, and data from the distant tail reveals that magnetic substorms observable on the earth are local manifestations of global phenomena in which magnetic field lines reconnect in the geomagnetic tail and pinch off huge regions of plasma that go hurtling off into space. The sojourn of ISEE-3 to the deep magnetic tail was made possible by unique three-body orbits involving the earth, the moon, and the spacecraft. Now ISEE-3 has changed its name to ICE and is off chasing comets.

In a blow-by-blow description—one that captures the excitement of scientists hot on the trail of discovery—Greg Stewart, Zachary Fisk, Jeff’ Willis, and Jim Smith tell us how they stumbled, with skill, onto what might be the first p-state superconducting metal. This compound of uranium and platinum, UPt_3, is a nearly magnetic material, one that exhibits substantial magnetic spin fluctuations; it therefore cannot be a superconductor of the ordinary s-state variety. In a sidebar David Pines. eminent physicist, Laboratory consultant, and expert in condensed matter physics presents a cogent interpretation of the observed phenomena and its significance for research in superconductivity. Also noteworthy is a sidebar in which expert crystal grower Zachary Fisk outlines the method he used to prepare single crystals of UPt_3.

Al Scott was among the original group of scientists who, in the late fifties and early sixties, followed their intellects into the unfashionable field of nonlinear science. He is obviously in love with this subject and in his interview in this issue is able to convey to the uninitiated its elusive concepts and the revolutionary impact they are having in science. Not only are nonlinear phenomena lurking almost everywhere but new mathematics has made it fun and productive to think about them. ■

On the cover.
A computer graphic showing the formation of a self-focused soliton-like excitation in the organic polymer acetanilide. This polymer, which resembles a protein, contains parallel chains of hydrogen-bonded peptide groups. The graphic depicts the time evolution of energy on one of these chains. Time increases from foreground to background. Energy increases from blue to yellow, purple, red, and green. Initially (at the base of the figure) energy is distributed uniformly along the whole chain (yellow). As time goes on, the energy self-focuses at a few sites along the chain (green peaks). Where energy is low on (he chain shown it is high on the other chains. This graphic displays results from GLOP, a computer code developed by Peter Lomdahl to calculate nonlinear dynamics for any protein geometry. The Davydov model on which the code is based is discussed in “Solitons in Biology” by Lomdahl, Layne, and Bigio. The graphic was prepared by Peter Lomdahl using Melvin Prueitt’s graphics program CAMERA.

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