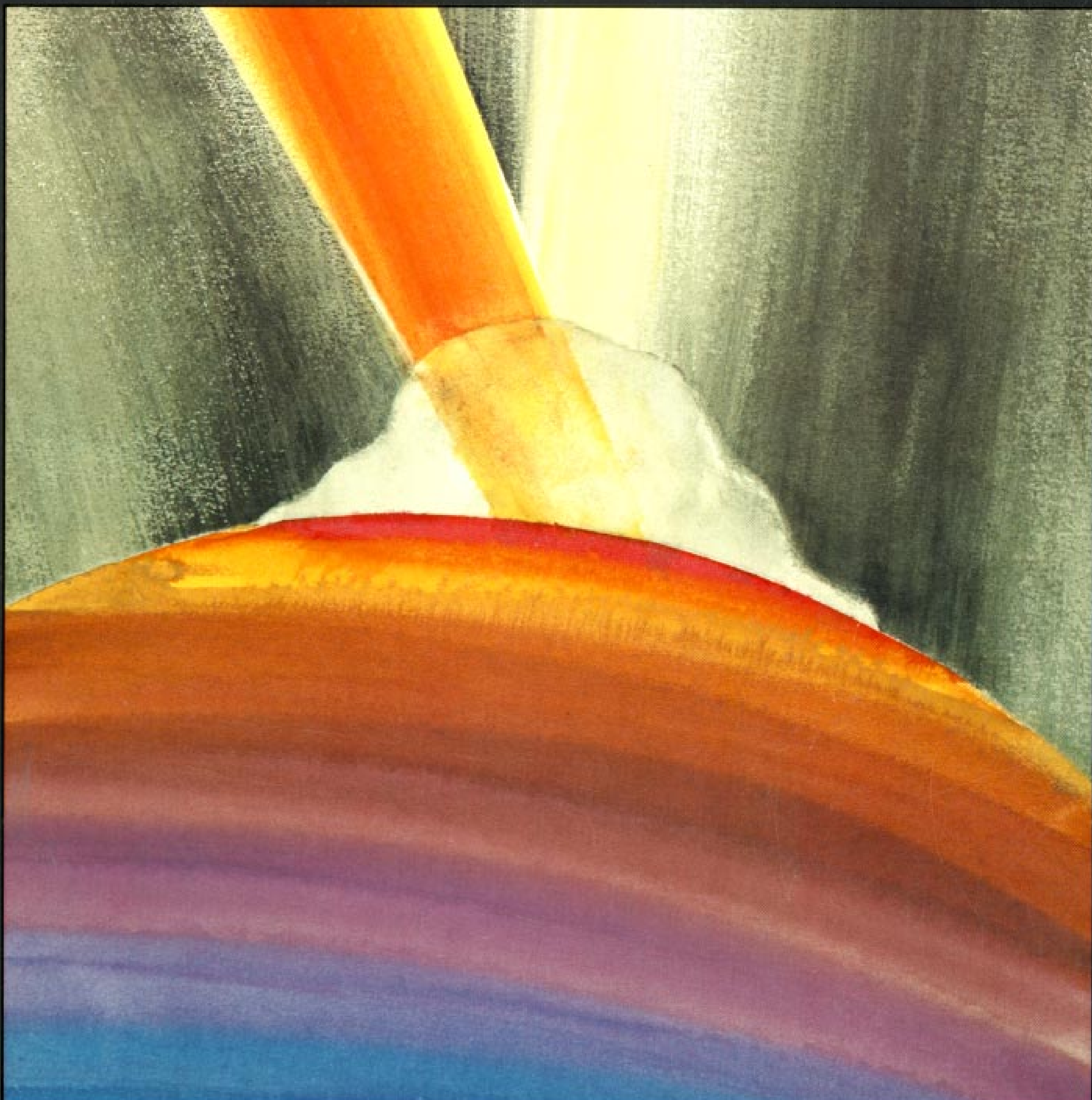
NUMBER 12 SPRING/SUMMER 1985

Los Alamos Science

LOS ALAMOS NATIONAL LABORATORY



EDITOR'S NOTE

In this issue we focus on some mainline interests of the Laboratory. The laser fusion program at Los Alamos is undergoing a change in direction—from work with long-wavelength $C0_2$ lasers at the Helios and Antares facilities—to work with short-wavelength lasers. Los Alamos originally chose the $C0_2$ laser because of its long-held status as the world's most efficient and economical laser. The philosophy was that it could be easier to design a small fusion target to accommodate the CO_2 laser than to invent a new laser.

A ten-year effort was made to uncover the mechanisms by which the energy of $C0_2$ laser light is deposited in a fusion target and to design targets that would direct those mechanisms toward the goal of efficient implosion. The story told by Dave Forslund and Phil Goldstone covers a mind-boggling array of new phenomena and new ideas—all discovered in the heat of programmatic promises and deadlines. We follow their path back and forth between hope and disappointment as they advance through the uncharted territory of laser-plasma interactions.

For years the project was banking on the creation of a steep density gradient in the absorbing plasma as the way to exploit long-wavelength laser light. The steep gradient enhances the collective process called resonant absorption. Unknown was how this process scales with energy. Does the absorption efficiency rise or fall as the laser intensity is increased by factors of 10 or more? The discovery that the steep density gradient is a short-lived phenomenon—one that decays through new types of plasma instabilities—came as a surprise and a devastating blow to the plans for $C0_2$-laser-driven fusion.

The blow to programmatic goals was tempered by the discovery of truly exotic processes. High-intensity laser-plasma interactions create enormous magnetic fields and produce rapid particle acceleration in ways that have never before been seen on earth. These processes offer possibilities for novel particle accelerators, for an approach to fusion that combines magnetic and laser fusion concepts, for studying the effects of new particle beam weapons, and for exploring dynamical mechanisms that might produce extragalactic radio jets.

Will we be able to use Antares to advance this new realm of plasma physics, or will this fabulous, space-age facility be abandoned like an old Hollywood movie set—standing idle because fusion monies won't be available to support it? How do we allow a major state-of-the-art facility to be planned and built with only a limited vision of what might be discovered there? We expect new findings, but we face them unprepared, lacking the flexibility to change directions and follow the new avenues of research. One could imagine such changes evolving naturally; instead they meet with endless reviews, endless requirements for justification, and the threat of imminent shutdown.

But people in this business are used to all that. Antares is just one among many continuing examples of the agonizing inefficiency brought about by the short funding cycles and the lack of long-range vision in American science.

What will happen next in laser fusion research at Los Alamos? First a concerted effort is being made to find adequate funding to continue work at Antares in high-energy plasma physics. Meanwhile, the hope for laser fusion is being placed on the development of a new short-wavelength laser driver—the KrF laser. It was always known that short-wavelength laser light would be more readily absorbed by a target than long-wavelength light. The problem was to develop a short-wavelength laser that was both powerful and efficient. Livermore invested in a high-intensity glass laser, but this laser has a low efficiency and places severe demands on the optical system. The KrF laser, discussed in this issue by program manager Reed Jensen, is a gas laser, which, though not inherently efficient, has been made so through a novel multiplexing system. At this moment spirits are high because the new design is producing more power than anticipated and is ahead of schedule. If all goes well, it will be ready for short-wavelength fusion experiments in just eighteen months.

The article by Mike Norman and Karl-Heinz Winkler on supersonic jets presents through numerical simulation the first self-consistent model for extragalactic radio jets. Exciting to the astrophysics community because it provides a means for understanding the structure and stability of those enormous cosmic eruptions, this work also provides a beautiful example of how to do basic science with a supercomputer. The computer is used as a numerical laboratory to investigate the phenomenology of a nonlinear system, and the essence of the physics is extracted through graphic representations of the solution. Mike and Karl-Heinz "clobbered the problem" with an unprecedented amount of computer power, orders of magnitude greater than that applied to any other problem in astrophysics and comparable to the amount usually devoted to studies of controlled fusion or nuclear weapon designs. They pushed their research tools to the limit, using all the memory of a Cray-1 computer and as much computer time as they could beg, borrow, or steal. The example they have set is sure to be followed by many as supercomputers become available to a wider and wider segment of the research community.

Reversing their usual competitive stance, Los Alamos and Livermore have joined forces in a most unusual project that is already advancing the rate of progress in medical genetics. Together they have become suppliers of human genes. That's right. You can order a vial of DNA fragments from the human chromosome of your choice. What can be done with such a vial? In "Genes by Mail," Livermore project leader Marv Van Dilla, Los Alamos project leader Larry Deaven, and other members of the Los Alamos team discuss how these so-called gene libraries will be used to aid basic research on gene structure and expression and to develop probes for diagnosing genetic diseases, for locating genes on chromosomes, and for detecting mutations and studying their role in adaptation and evolution. They also discuss gene therapy, an exciting prospect of research in medical genetics.

This issue ends with a philosopher's challenge—a challenge we may be tempted to ignore, especially those of us who believe that who we are and how we perceive is explainable in terms of the causal objectivity usually applied to the physical world. Upon closer examination, however, the strict dichotomy between objectivity and subjectivity breaks down. The role of intention is seen to underlie not just our actions and thoughts, but every act of perception as well. And intentionality implies the element of choice, another complication we might like to ignore. But ignore it we can't, because in our attempts to understand ourselves in scientific terms and to build machines that imitate human intelligence and human behavior, we are brought face to face with our very limited understanding of the nature of conscious acts. Gian-Carlo Rota and David Sharp, in their dialogue on mathematics, philosophy, and artificial intelligence, point to this confrontation as the central drama of our time, one that will bring about a major revolution in our understanding of ourselves.

This issue contains some warnings and some prophetic visions of the future. One is the revolution in research that is now at our doorstep, brought about by the enormous power of computers to unravel complex phenomena. Another is the revolution in medical genetics that promises a radically new approach to diagnosis and care. Finally, and most profound of all, there is the intellectual revolution, the revolution in awareness that will come as we attempt to use computers to mimic human function. ■

Necia Grant Cooper

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Los Alamos Science. is published by Los Alamos National Laboratory, an Equal opportunity Employer operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

Address Mail to
Los Alamos Science
Mail Stop M708
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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On the cover (and overleaf).
The ion jet (white column) is a dramatic example of the exotic physics generated when high-intensity CO_2 laser light (yellow column) impacts the surface of a laser fusion target (sphere). The colors of the target represent the extreme magnetic fields that encircle the spot and help drive the highly collimated plume of ions from the surface.