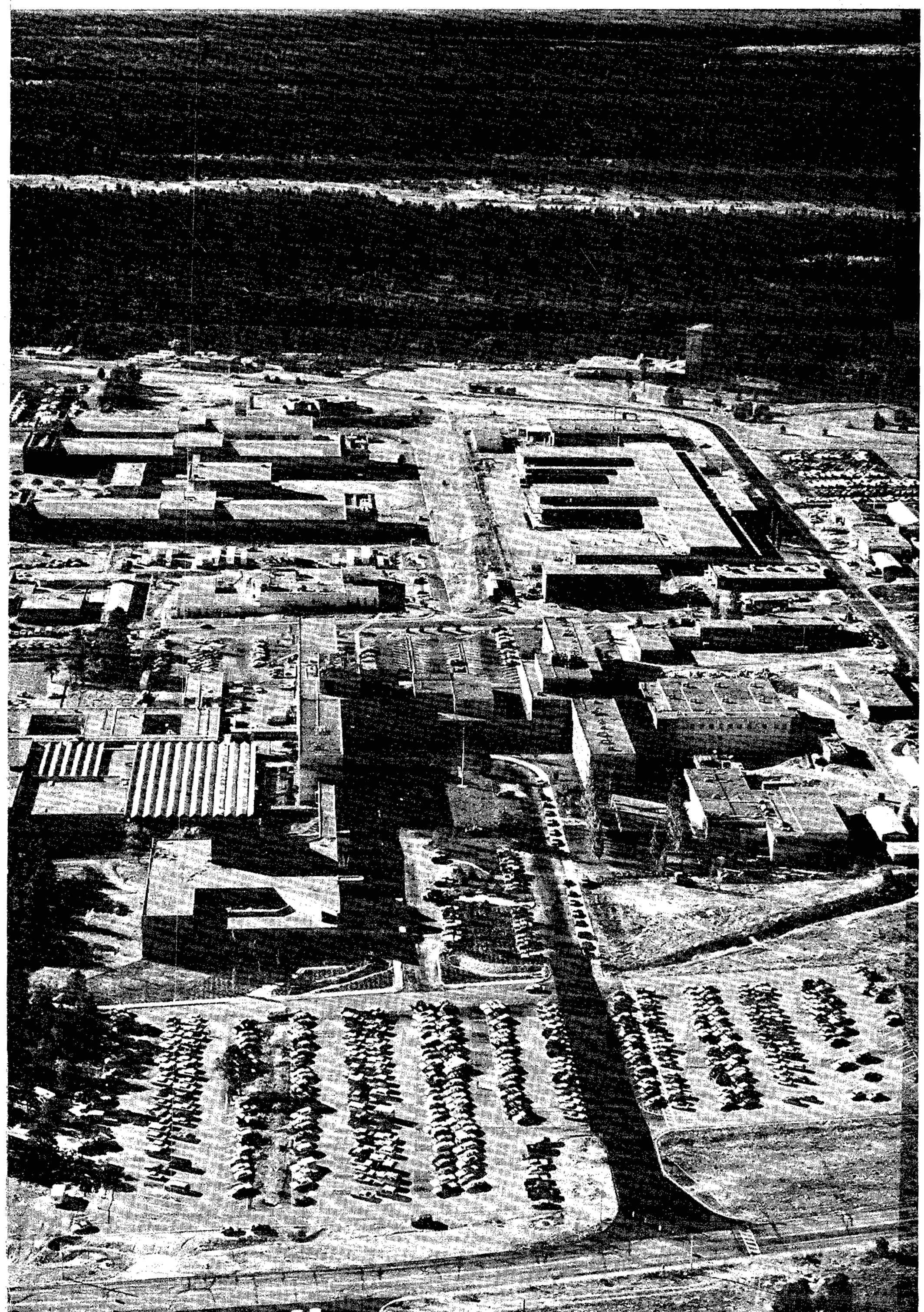
PREMIER ISSUE SUMMER 1980

Los Alamos Science

LOS ALAMOS SCIENTIFIC LABORATORY



EDITOR
Necia Grant Cooper

ART DIRECTOR, DESIGN, PRODUCTION
M. A. Garcia

ASSOCIATE EDITOR
Betty Leffler

EDITORIAL STAFF
DyAnne J. Short (Editorial Assistant)
Elaine Stanlick (Assistant Editor)
Dorothy Amsden (Contributing Editor)

PHOTOGRAPHY
LeRoy Sanchez (Portraits)
Group ISD-7

ILLUSTRATION
Anita Flores
Jim Mahan
Vicki Hartford
Gail Flower
Group ISD-3
Les Speir (Cartoonist)

COVER GRAPHICS
Bob Hotchkiss

PRODUCTION
Jo Ann Painter (Photocomposition)
Barbara Velarde (Photocomposition)
Judy Carlson
Gloria Riepe
William H. Regan
(Printing and Technical Coordination)

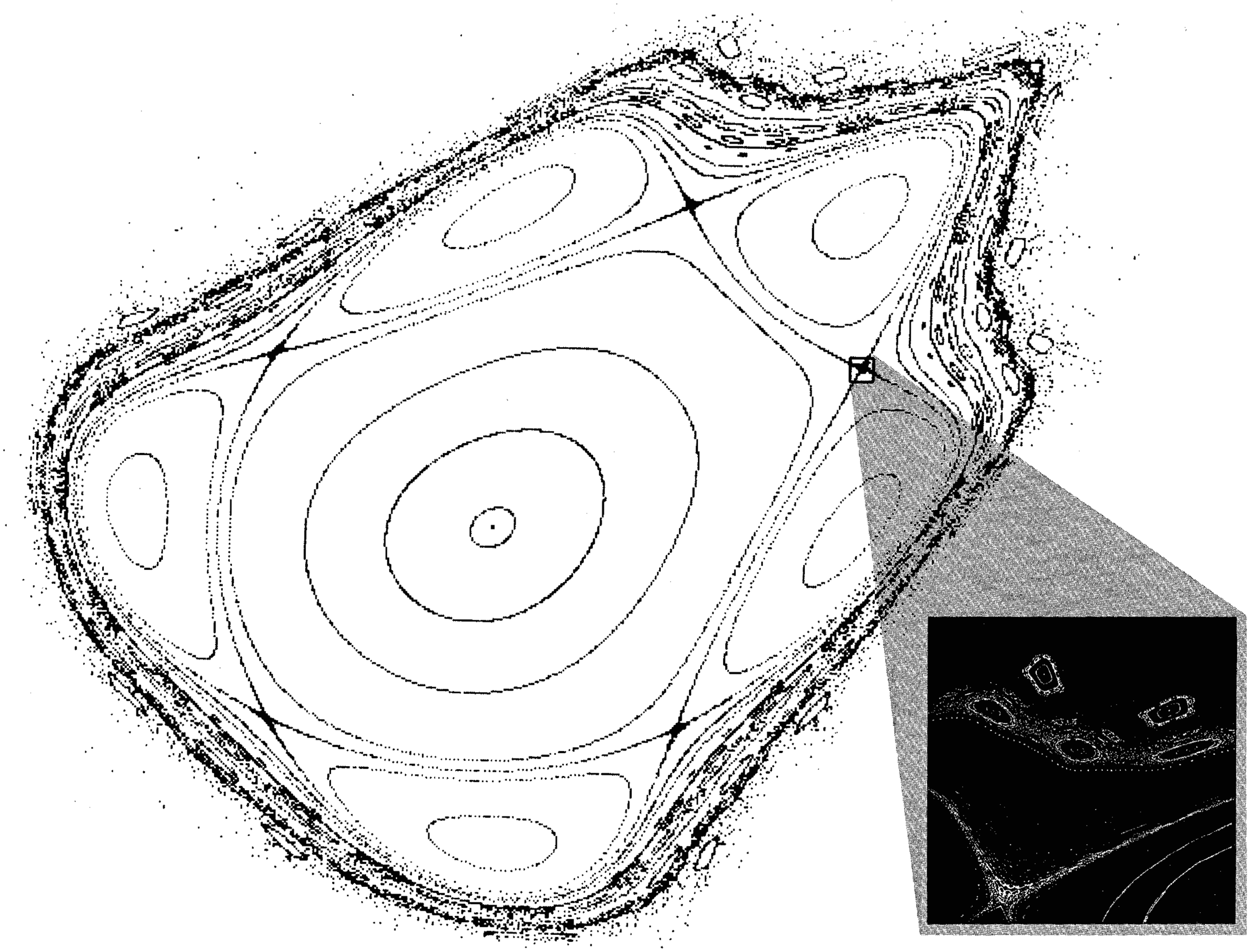
Volume 1, Number 1

Los Alamos Science

LOS ALAMOS SCIENTIFIC LABORATORY

CONTENTS

Published 4 times a year by the University of California, Los Alamos Scientific Laboratory, Bldg. SM-43, Casa Grande Drive. Second class mailing permit pending approval at the Los Alamos, NM Post Office.
Address mail to MS-103, P. O. Box 1663, Los Alamos, NM 87545. Telephone (505)667-3905.
Los Alamos Scientific Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the United States Department of Energy, under contract W-7405-ENG-36 Modification No. 187.



ON THE COVER: The cover figure was chosen to illustrate how an elementary two-dimensional transformation can exhibit unfathomably complex behavior — it is actually a blow-up of the boxed region in the figure shown alongside it.

The transition from simple to complex or pseudorandom behavior through period doubling in a large class of nonlinear dissipative systems can now be described quantitatively with the universality theory invented by Mitchell Feigenbaum and described in "Universal Behavior of Nonlinear Systems." The transformation depicted in the figure is an area-preserving map corresponding to an energy-preserving rather than a dissipative system. This type of system is known experimentally to proceed through period doubling, and Mitchell hopes to extend the universality theory to handle this Hamiltonian-type system.

The figure was constructed by taking first one and then another initial point (x,y) and iterating it under the transformation

$$x' = x^2 - y$$

$$y' = a + x$$

where $a = -0.4224$. This quadratic transformation preserves elements of area and can be viewed as a model Poincaré map of a Hamiltonian system; for example, a piston supported under gravity by a one-particle gas produces a similar Poincaré map.

The 50 or so initial points used to generate the cover figure can be decomposed into two sets. Those of the first set produce iterates that lie on ellipse-like curves. For example, three initial points produced, respectively, the central yellow dots, the smaller inside yellow ellipses, and the larger yellow ellipses inside the chain of nine yellow "island" ellipses. One initial point produced the central dots of both yellow clusters (as well as those of similar yellow clusters outside the viewing area). These points of the second set produce a "haze" of iterates, which wander randomly through certain regions of the figure. For example, the lavender haze surrounding the three lavender island clusters is produced by just one initial point. It is this haze that corresponds to the statistical behavior of the system. The complexity is far greater than illustrated here. In fact, a magnification of the lavender haze midway between two of the islands would show a similar constellation of islands and haze, and so forth, ad infinitum.

This behavior may be viewed as the consequence of an instability — such as in a plasma — that has led to an uncontrolled behavior of the system. In the Hamiltonian analogue, the whole plane is a surface of constant energy. A system obeying statistical mechanics should have wandered over the entire plane. Evidently the present system fails to do so, with a given point often found to circulate around one of the elliptical islands, or "invariant tori." The presence of these tori constitutes a violation of statistical mechanics, and their presence turns out to be insured by a famous theorem (KAM). A hope to establish the validity of statistical mechanics for a classical system is to determine how these tori may be destroyed with increasing dimensionality. Since period doubling is the route that successively destroys these tori, an extension of the present universality theory may describe this process quantitatively. The theory's extension is not yet worked out, but work is in progress. Apart from some understanding of how a Hamiltonian system comes to behave ergodically, there is the hope in the opposite direction that, having comprehended a general route to instability, an understanding of how to prevent this might come about. Such information is, of course, of crucial significance in the problem of magnetic fusion.

INSIDE THIS ISSUE

EDITOR'S NOTE

The impact of scientific discovery on the nature of our world has nowhere been felt more poignantly than by the first scientists at Los Alamos. Since the 1940s the Los Alamos Scientific Laboratory (LASL) has changed dramatically, enlarging and diversifying to the point where it is no longer just a weapons laboratory. Today it is a multipurpose institution concerned with the advancement of science and the solution of energy and defense problems. As a national laboratory, LASL seeks a complementary role vis-a-vis academic research, industrial development, and government policy, with the nature of that role still emerging. Clearly though, its many unique and significant contributions to science, to technology, and to society will continue to influence decisions on a broad range of national issues.

In this magazine, we hope to provide a forum for scientists and engineers at LASL to present their work to each other and to the wider community in a fashion that promotes understanding. This entails sharing personal insights into the broader implications of the work and the political issues that provide the context for it.

The exciting interplay between basic and applied research at LASL provides fertile ground for new ideas. The cover story, "Universal Behavior in Nonlinear Systems," is a good example. Upon coming to Los Alamos, Mitchell Feigenbaum was urged by Peter Carruthers, Theoretical Division Leader, to attempt an investigation into the nature of turbulence, a phenomenon that inhibits progress in many major technological programs. The result is the universality theory and the first quantitative understanding of how causal systems develop chaotic behavior. The ideas are new and fascinating and Mitchell has used his rare pedagogical skills to present them here. The presentation is by necessity much more technical than the others in this issue, but is well worth the reader's time.

"High-Temperature Superconductivity" is somewhat like a detective story, beginning with a mystery, following the false leads, and finally coming upon an intriguing solution. We began planning this article amidst conjecture and confusion as to the true interpretation, but the authors' enthusiasm ran high as they rapidly exploited a variety of measurement techniques available to them at LASL to piece together all the elements of the puzzle.

The focus on nuclear technology at LASL has always included studies of radiation effects on biological organisms. In the late 1960s, the biologists' need to understand radiation effects at the cellular level combined with the physicists' techniques for measurement and analysis to create a new research tool.

Known as the flow cytometer, this extraordinary instrument interrogates and sorts thousands of cells per second with high statistical accuracy. It is being used to investigate a host of problems in cell biology, including the morphology of individual chromosomes and the changes that accompany the transformation of a cell from normal to malignant. The story of its invention and its application to problems in cancer research are described in this issue.

In the midst of the raging antinuclear debate in this country and the expansion of the nuclear industry abroad, we present as our program feature the Nuclear Safeguards Program. Bob Keepin, considered by many to be the father of modern safeguards measurement technology, and a long-time participant in international negotiations on nuclear power and safeguards agreements, gives us a historical perspective on safeguards issues and a personal insight into LASL's contributions. The nuts and bolts of the LASL program are described in the two follow-up articles: an in-depth review of nondestructive measurement technology and its use by the nuclear industry, and a step-by-step description of how one designs a materials accounting system to deter a knowledgeable insider from diverting strategic nuclear material. An editorial by Don Kerr, LASL's Director, urges support for safeguards technology development and implementation in these troubled times of political terrorism and economic uncertainty.

The Laboratory's history is notable for the continued participation of great men of science. Willy Zachariasen was one, and from Bob Penneman's moving memorial to his long-time friend and collaborator we learn more about the man, his work, and his unique contribution to the Manhattan Project.

Few things are more stimulating than hearing one's implicit assumptions identified and challenged by new points of view. We encourage our readers to respond by contributing their own perspectives on the issues and ideas that appear in *Los Alamos Science.*

Necia Grant Cooper