SYMMETRY AND COMPLEXITY

THE SPIRIT AND BEAUTY OF NONLINEAR SCIENCE

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SYMMETRY AND COMPLEXITY

THE SPIRIT AND BEAUTY OF NONLINEAR SCIENCE

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The Spirit and Beauty of Nonlinear Science

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Preface

Symmetry and complexity determine the spirit of nonlinear science. The expansion of the universe, the evolution of life and the globalization of human economies and societies lead from symmetry and simplicity to complexity and diversity. The emergence of new order and structure means symmetry breaking and transition from unstable to stable states of balance. It is explained by physical, chemical, biological, and social self-organization, according to the laws of nonlinear dynamics. Atoms and molecules, stars and clouds, organisms and brains, economies and societies are only some examples of dynamical systems. Thus, symmetry and complexity are the basic principles of a common systems science in the 21st century, overcoming traditional boundaries between natural, cognitive, and social sciences, mathematics, humanities and philosophy.

This book treats the essence of my scientific work that can be described by a kind of dialectical triad. In a first step, I published a comprehensive treatise on *Symmetries of Nature* in 1988 (English: 1996). Early studies in geometry and space-time had inspired my interest in mathematical invariance and universal laws. As many other scientists, philosophers, and artists, I was also fascinated by the beauty of mathematical symmetries. But, physical, chemical, and biological symmetries are broken by natural processes, leading to the observed complexity and diversity of the world. Therefore, I studied the foundations of nonlinear dynamics and, as a second step, published the book *Thinking in Complexity*. The

Complex Dynamics of Matter, Mind, and Mankind in 1994 (4th enlarged edition 2004). My interest in complexity dates back to my Ph.D. thesis on the foundations of constructive mathematics and computational degrees of complexity in 1973. In many other books and articles, I enlarged the applications of nonlinear systems to computer science, cognitive science, and social science. After thesis and antithesis, this book is the synthesis of *Symmetry and Complexity*. It also connects my life-long love of music and art with nonlinear science.

Research is always realized in a network of cooperation and communication. Therefore, I want to thank some colleagues, friends and institutions. Leon O. Chua (Department of Electrical Engineering & Computer Sciences, University of California, Berkeley) invited me to publish a book in his series on Nonlinear Science. He is also the editor of the *International Journal of Bifurcation and Chaos in Applied Sciences and Engineering*. As a member of the editorial board of this journal, I have the opportunity to get an interdisciplinary overview of worldwide explorations in nonlinear science. Symmetry and complexity are also topics of international and cultural integration. International translations of my books underline the interest in symmetry and complexity beyond all cultural boundaries. I would like to thank the European Academy of Science (Academia Europaea in London) who invited me for a lecture on symmetry and complex systems in January 2005. Furthermore, I would like to thank the Leibniz-Community of German Research Institutions and the Japanese Research Institute of Integration Science for their kind invitation on a lecture on complex systems in October 2004. Thanks also to Hermann Haken and Wolfgang Weidlich (Institute of Theoretical Physics, University of Stuttgart), Jürgen Mittelstraß (Department of Philosophy, University of Constance), Martin Quack (Laboratory of Physical Chemistry, ETH Zürich), and Alwyn Scott (Department of Mathematics, University of Arizona) who have inspired and supported my work.

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Augsburg and Munich, September 2004

Klaus Mainzer

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