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Physics of complex systems

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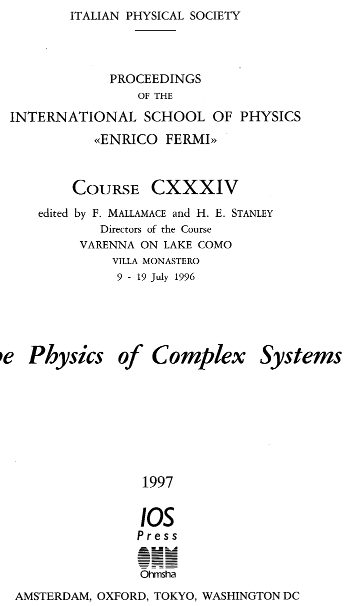
"No satisfactory definition of complexity has been here provided: each speaker has presumed some familiarity with the concept without putting in into discussion."
F.T.Arecchi, p. 53


ITALIAN PHYSICAL SOCIETY

PROCEEDINGS
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COURSE CXXXIV
edited by F. MALLAMACE and H. E. STANLEY
Directors of the Course
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The Physics of Complex Systems

1997
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AMSTERDAM, OXFORD, TOKYO, WASHINGTON DC

This book was published in 1997 in the series "Proceedings of the International School of Physics "Enrico Fermi" and contains the lectures and contributions presented at the CXXXIV Course of Enrico Fermi School held 9–19 July 1996 in Varenna on Lake Como, Italy. The editors and the directors of the Course were F.Mallamace and H.E.Stanley. The Course focuses on a "state-of-the-art" level of modern problems in the physics of complex systems and provides both an overview of the field and a detailed examination of the main topics within the field that are currently of greatest interest to researchers.

Physics of complex systems is a rather new research area, which was established during a few last decades. The research field of complex systems is very broad and includes a variety of different and overlapping areas in physics, chemistry, biology, economy, mathematics, and technology. Thus, as it is mentioned by the organizers, one of the main aims of the Course was to stimulate the search for a unified approach to the area by gathering together researchers from a variety of specialized backgrounds: the Course faculty included 15 lecturers and 18 invited seminar speakers.

The book contains a collection of 27 lectures and 31 poster contributions, which provide an overview of the present status of the physics of complex systems and present recent achievements in the field. They cover a broad area of interdisciplinary studies and can be grouped into several main topics. Among them are: scaling properties and universality; supramolecular systems; aggregates, aggregation kinetics,

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pattern formation and disorderly growth mechanisms; granular matter; polymers, associating polymers and gels; amphiphiles, microemulsions and colloids; membranes, interface phenomena and geometry-constrained dynamics; phase separation and out-of-equilibrium dynamics; supercooled fluids and glass transition; turbulence, chaos and chaotic dynamics.

In his lectures P.G. de Gennes presents both the theory and some technical applications of granular matter. Problems of non-equilibrium pattern formation and spatiotemporal chaotic arrangement are discussed by F.T.Arecchi. In paper of J.Klafter, G.Zumofen and M.F.Shlesinger the main properties of long-tailed distributions and non-Brownian transport in complex systems are discussed in their relationship to subdiffusive and slow relaxation. In lecture by S.Havlin *et al.* the problem of fractal correlation in medicine and biology is reviewed. P.D.Kaplan and A.Libchaber report recent achievements and developments on physics of proteins. In report by N.A.M.Verhaegh and H.N.W.Lekkerkerker phase transitions in colloids and colloidal solutions are discussed, and an overview of the structure and kinetics of phase-separating colloidal suspensions is given. Kinetics of spinodal decomposition in gels is considered in the paper of R.Bansil and G.Liao. Water-in-oil microemulsion system and the role of surfactants are studied in papers of S.-H.Chen and his collaborators, and special emphasis is done on such properties as surface adhesion, percolation and surface curvature in bicontinuos phase. Other significant topics in this area are also presented in separate contributions of: H.Hoffmann, F.Witte, and J.Würtz, where the influence of the cosurfactant/surfactant ratio on the stationary birefringence and reological properties of perfluorousurfactants is studied; and A.Robledo and C.Varea, where a simple interpretation of the microemulsion phase diagram in terms of the kinetics of phase separation of two immiscible solvents is presented. Macroscopic dynamics of wetting and dewetting processes are discussed in paper of F.Brochard-Wyart *et al.*

In the introducing lecture by F.Mallamace and H.E.Stanley an overview of the basic ideas of the scaling symmetry concept and universality in physics is given. Considering complex system as a collective of a large number of interacting subunits, the authors formulate the principle of universality which is reflected in the empirical fact that quite different systems can have remarkably similar behaviour, in particular near critical points. Hence, the ideas of scaling and universality may have utility in explaining a range of complex systems. In continuation of this topic E.Family discusses some applications of scaling in dynamics of surfaces and interfaces. In papers of S.V.Boldyrev *et al.* and R.N.Mantegna and H.E.Stanley the interesting applications of scaling ideas in modeling of company growth and development of financial markets are reported. A.J.Mandell, K.A.Selz and M.F.Shlesinger consider the problem of similarities of amino-acid sequences of protein families according to its hydrophobic free energy properties.

Dynamical properties of complex fluids in the hydrodynamic regime and, in particular, Brownian motion are considered by R.Klein for colloidal suspensions. Beginning with the first principles, L.Bocquet and J.-P.Hansen consider the structure and dynamics of suspensions. Specific features of Brownian motion in confined systems are discussed by L.Lobry and N.Ostrowsky. Common features of relaxation phenomena in dense disordered systems are considered by P.Tartaglia.

In several complementary lectures the problems of the glass phase transition and some key aspects of the glassy state are discussed. A.Coniglio reports on cluster structures and frustration in spin glasses, glasses and granular materials. Some simple models of glasses and specific features of slow dynamics in glassy systems are discussed by G.Parisi. Recent important impending achievements for strongly and fragible liquids are reported by C.A.Angell. In particular, in C.A.Angell's paper the problems of nucleation kinetics and growth as well as understanding of diffusion mechanism in the relationship to other relaxation processes are discussed in detail. Related to this area are the contributions of F.Sciortino and A.Bunde. Elastic stability criteria for crystals and the pressure-stimulated elastic instabilities, which drives the system toward amorphization, are discussed by M.Tang and S.Yip.

Summarizing, the conclusion can be drawn that the book of Proceedings "Physics of Complex Systems" gives an excellent view on the current state of the field, even after more than 5 years since the Course time. Of course, this book cannot be considered as comprehensive, because the research area of complex systems is extremely broad and quickly developing. However, the Course has to be considered as an important contribution, which allows us to have a deep insight into the physics of complex systems. This book will be very useful for people interested in this area, whether beginning graduate students and advanced research professionals. The only remark, which can be regarded as a critical one, concerns the quotation, given at the beginning of this paper – it is still difficult to understand properly, even after careful reading of the book, what is the key point in definition of complexity. One may think that the complex systems can be defined as complex one just because they are not so simple. Otherwise, the attempt to specify the subject of physics of complex systems, involving a large number of interacting subunits and possessing similar properties at least near some critical points, made in the introducing paper of F.Mallamace and H.E.Stanley, needs further development and has not been considered, unfortunately, as the dominant one in the most papers presented. Therefore, misunderstanding of this point may create some inconveniences to the readers trying to learn more about such a new and exciting field as the physics of complex systems.

The best compliments should be addressed to the editors and the lecturers for their hard work, and to the readers the reviewer wishes to enjoy the Book.

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