

Preface

This book is intended for graduate students familiar with the elementary notions of thermodynamics and statistical physics, and with the usual methods of mathematical physics: ordinary and partial (linear and non-linear) differential equations, dynamical systems, matrix algebra and basic differential geometry. Its reading does not require any special preparation beyond a fair practice of the above notions. It is accessible to any physicist interested in new vistas in the domain of non-crystalline condensed matter, aperiodic and quasi-crystalline networks and especially glass physics and chemistry.

Most of the material covered here is based on the series of lectures I delivered in the LENS research center in Florence (Italy) and in the Technion in Haifa (Israel), as well as in a regular graduate lecture program at the University of Paris-VI. The lectures were devoted mostly to the physics of glasses, focusing on their thermal and mechanical properties and analyzing various models of processes leading to the formation of the glassy state of matter from overcooled liquids. The models of agglomeration and growth were also applied to describe the formation of quasicrystals, fullerenes and capsid viruses, and these results are also covered in this volume.

My original scientific training was in theoretical and mathematical physics, centered on gravitation, cosmology and elementary particles, with mathematical tools including differential geometry, functional analysis, group theory and topology. In the seventies I took an interest in magnetic monopoles, and was quite naturally led to study topological defects and their classification. Reading current literature on the subject I discovered the papers on defects in solids written by M. Kléman, J.-F. Sadoc and R. Mosseri, as well as the earlier papers by L. Michel and G. Toulouse; soon after that I read the fascinating papers by N. Rivier.

My thanks go first to Maurice Kléman and Nicolas Rivier who very early on encouraged me to work on amorphous solids. I am very grateful to my colleague Minko Balkanski who followed my first steps in glass science and introduced me to the experimental and theoretical work on borate glasses. Michel Massot and other members of Balkanski's group showed me their experimental data and helped me to understand and to interpret them in the spirit of the theoretical models I was elaborating at that time.

I am greatly indebted to the late Frank L. Galeener who shared with me his experimental results on glasses and introduced me to the main concepts of glass physics. His visit to Paris in 1988 and our common work on rings in amorphous SiO_2 are still vivid in my memory. It was also Frank who brought Rafael A. Barrio into the collaboration, which has continued fruitfully until today. He also invited me to glass physics workshops in Boston and Nashville, where I discovered a vibrant community of scientists eager to share their knowledge and to open their field to the new methods I tried to introduce. It was a privilege to meet personally and to discuss with such eminent glass physicists as the late Norbert Kreidl and Alex Cooper. The contact with glass scientists like Richard Zallen, Robert Weeks, Rod Devine and James C. Phillips greatly contributed to the progress of my work. In 1994, a year after Frank Galeener's untimely death, a Colloquium in his memory was organized in Winter Park, Colorado. I met there, besides J.C. Phillips and M. Balkanski, other eminent glass physicists, Punit Boolchand, Roger J. Elliott, Michael F. Thorpe, and many others. Since then, a lasting friendship has developed from our discussions and collaborations.

The stochastic agglomeration theory which is the unifying and basic element of this book could not be elaborated without the invaluable contributions of my Ph.D. students Dina Maria dos Santos-Loff, Matthieu Micolaut and Ondrej Mares, and my collaborators Jean-Paul Duruisseau, Rafael Barrio and Ruben Aldrovandi. Rafael Barrio's Ph.D. student Gerardo G. Naumis spent a year in Paris greatly contributing to the development of agglomeration models and Philippe Jarry provided me with many experimental results obtained during his Ph.D. work under the direction of Pascal Richet. Punit Boolchand and his research group in Cincinnati contributed greatly during last few years.

In 1999 I participated in Glass Physics and Chemistry Colloquium organized by Yu. S. Tveryanovich at the Chemistry Department of the University of St. Petersburg. There I met there many prominent Russian scientists, among whom the late S.A. Dembovsky (deceased in 2003), A. Bal'makov, A. S. Tver'yanovich, V. Maslyuk, V. Mazurin and many others. I was

greatly impressed by the Russian school of glass science, whose ideas are also incorporated here.

Quasicrystals became a very hot topic in the eighties, and I was naturally attracted by the beautiful and fascinating properties of Penrose tilings. Many discussions with Peter Kramer and H.R. Trebin, whom I was able to invite for short visits to Paris, helped me to understand many mathematical aspects of quasicrystals and other aperiodic structures. I learned a lot about Penrose tilings from Maurice Kléman and his brilliant Ph.D. student André Pavlovitch, who died tragically in 1994. The fullerenes became another fascinating topic which emerged at about the same time. It was André Rassat who introduced me to this new branch of physical chemistry. I used the agglomeration models to describe fullerene nucleation and growth, collaborating for several years with K.H. Bennemann of Berlin and my colleague K.A. Penson.

The agglomeration models can be also used in biology, in particular in virology, for mathematical description of virus assembly pathways. I have become aware of this fact due to Reidun Twarock's papers on this subject, and I was eager to apply the methods elaborated for physical models to this new domain. Nicola Stonehouse helped me to understand the basics of capsid construction. Some recent results are incorporated in this book.

I wish to express my thanks to friends and relatives who constantly helped me during the preparation of this book. Andrew Chan Y. Tong, Jerzy Karczmarszuk and Jacques Kerner produced many figures I was unable to do as well myself. Pawel Blasiak and Pascal Viot helped me to tame my stubborn computers, and Allan Solomon kindly supervised my English. I am also indebted to Bertrand Guillot, the Director of the Laboratoire LPTMC, for a friendly and creative scientific atmosphere.

Finally, my deep and greatest gratitude goes to my wife Grażyna who supported me with much understanding and loving care while I was working on this book.

Richard Kerner, Paris, September 2005