Preface

Spreading phenomena are encountered almost everywhere in our world. They may concern ideas and conceptions as well as real objects and range from sub-microscopic up to galactic distances, with timescales in the blink of an eye to geological time. With the existence of atoms and molecules, nature has provided us with a miraculous playground for experiencing the fascination of spreading phenomena which, in this context, are generally referred to as diffusion. Theoretical concepts developed in the study of diffusion of atoms and molecules have proved to be of great benefit for exploring spreading phenomena with a large spectrum of objects, irrespective of the diversity of their properties and of the underlying mechanisms. Treatises and reviews of spreading phenomena therefore frequently exploit the common ground offered by the similarities in their mathematical treatment. Such concepts are well suited for developing skills in analyzing and modeling spreading data, but they often fail to provide detailed understanding at a more fundamental level.

By aiming at an insightful introduction into the fascinating diversity of spreading phenomena in nature, technology and society, the present textbook attempts to fill this gap in the existing literature.

The roots of this book may be traced back to the breakdown of the Berlin Wall and the option of a workshop series, sponsored by the Wilhelm and Else Heraeus Foundation under the auspices of the Physical Society of reunited Germany, which brought together scientists from both parts of Germany as well as from other countries. One of these workshops, organized in Leipzig in autumn 1996, was dedicated to “Diffusion in Condensed Matter.” It dealt with that topic in unprecedented width and depth. Two textbooks (J. Kärger, P. Heitjans, R. Haberlandt “Diffusion in Condensed Matter,” Vieweg 1998, and P. Heitjans, J. Kärger “Diffusion in Condensed Matter: Methods, Materials, Models”, Springer 2005) emerged from this initiative and are still regarded as follow-ups to Wilhelm Jost’s famous textbook on “Diffusion in Solids, Liquids and Gases,” Academic Press 1960.

The idea of intensifying scientific exchange across the boundaries of the individual disciplines gave rise to the establishment of the “Diffusion Fundamentals” conference series, accompanied by an open-access online journal (diffusion-fundamentals.org).

Given the relevance of physical sciences for the development in the field, it was certainly not by chance that the first conference in this series was held in Leipzig in 2005 to celebrate the centenary of Albert Einstein's annus mirabilis. Subsequent meetings in L'Aquila 2007, Athens 2009, Troy 2011 and Leipzig 2013 strove to cover with increasing concern the large spectrum of diffusion and spreading phenomena until, in 2015, the Diffusion Fundamentals activities were assigned to the Saxon Academy of Sciences. As one of Germany's regional Academies of Sciences (with members of the three Central German Federal States Sachsen, Sachsen-Anhalt und Thüringen), it stands in a great tradition (with, e.g., Werner Heisenberg as one of its secretaries) and offers, with Classes of Mathematical-Natural, Philological-Historical and Engineering Sciences, ideal conditions for cross-disciplinary scientific exchange. The participants of the 6th Diffusion Fundamentals Conference in Dresden 2015 no doubt benefited from this new level of interdisciplinary contact, and we hope that, with the contributions to the present volume which largely follow the contributions to the conference, this benefit may now be passed on to the readers of the book.

With informative illustrations, we did our best to follow the saying that a single picture tells more than a thousand words. This may also be true for a single mathematical formula—provided that the actual situation does indeed allow such a description and that the underlying mathematics remains within certain limits of comfort.

In our contact with the authors of the different chapters, we became aware of the criticality of both these issues. In some types of systems, such as human societies, the available information is not sufficient to provide meaningful predictions of future developments. In such cases, the chapters have to be presented without precise mathematical formulations. Other systems, notably those accessible by investigation with the highly sophisticated techniques of measurement provided by modern physics and chemistry, offer a multitude of information so that data processing may become quite ambitious. While all our chapters start their mathematical treatment with nothing more (but, notably, with also nothing less) than school mathematics, a few of the chapters progress to more advanced topics requiring more sophisticated mathematics. We have intentionally chosen problems from the frontiers of research, i.e., beyond the "diffusion main stream." Topics such as "Phase Transitions in Biased Diffusion" and "Hot Brownian Motion" might thus appear to be somewhat challenging. We trust, however, that the interested reader will take this as an invitation to browse some of the more specialized literature.

With all chapters now in our hands, we have first to thank the authors for a most agreeable cooperation. Looking back at the genesis of the book, we have to thank all who have contributed to the development of the "Diffusion Fundamentals" activities, including Leipzig University as the venue of the first conference, Dresden Technical University as the location of the sixth conference from which this book is derived, and the many colleagues all over the world who have cooperated with us as members of the Diffusion Fundamentals Editorial Board. We appreciate generous support by the Saxon Academy of Sciences and, over the course of the whole Diffusion Fundamentals Conference series, by the German Research Foundation, the Alexander von Humboldt Foundation and the Fonds der Chemischen Industrie.

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