Nuclear neighbors mull their fate

Complex Plasmas and Colloidal Dispersions

Particle-Resolved Studies of Classical Liquids and Solids

Alexei Ivlev, Hartmut Löwen, Gregor Morfill, and C. Patrick Royall
World Scientific, Hackensack, NJ, 2012. $78.00 (320 pp.).
ISBN 978-981-4350-06-8

Charged particles 1–10 microns in size and suspended in an ionized gas constitute what is called a complex, or "dusty," plasma. The same particles suspended in a liquid make a colloidal dispersion. Depending on the nature and strength of the interactions between them, the particles in either system can adopt structural arrangements that are the analogs of atomic gases, liquids, and solids. A striking feature is that because of the long range of the Coulombic repulsion between the particles, both plasma and colloidal crystals can be dilute, with lattice spacings of many particle diameters. Particles in this size range can be imaged accurately for the determination of structure, and their motions can be followed by video microscopy.

Complex Plasmas and Colloidal Dispersions: Particle-Resolved Studies of Classical Liquids and Solids is the fifth and latest volume in a soft-condensed-matter series started by Pierre-Gilles de Gennes. Of the authors, Alexei Ivlev and Gregor Morfill are leaders in the study of complex plasmas, Patrick Royall is a colloid experimentalist specializing in imaging, and Hartmut Löwen is a theorist who covers a broad range of soft-matter topics.

The book emphasizes the use of plasmas and colloids to study fundamental phenomena, particularly nonequilibrium processes such as crystallization and glass formation, and the effects of external forces including gravity, electric and magnetic fields, and shear. Another motivation, which the book does not explicitly address, for studying the two systems is their practical importance. Dusty plasmas occur widely in the atmosphere and in space and are important in industrial processes such as computer-chip production. Colloidal dispersions are ubiquitous in everyday life, in such products as foods, paints, glues, cosmetics, and medicines.

After an introduction, chapters 2 and 3 deal with the basic properties of complex plasmas and colloidal dispersions: how the particles become charged and the nature of their interactions, including how external fields affect the interactions and other properties. Chapter 4 compares the two systems. For similar interactions, the structural arrangements of the particles in the two are the same, but the dynamics—that is, the particles' thermal motion—are fundamentally different. In the dilute ionized gas of plasma, the particle motions are underdamped and obey simple Newtonian dynamics; in a dense liquid, the motions of colloidal particles are overdamped and are well described in terms of Langevin dynamics (or Brownian motion). These important differences are emphasized later in the book. Chapter 5 contains a description of the equipment used to study plasmas, a brief section on the preparation of colloids, and a survey of video microscopy and particle tracking.

The remaining two-thirds of the book covers various phenomena associated with both systems, under the headings Simple Liquids, Liquid-Solid Phase Transitions, Binary Mixtures, Slow Dynamics, Driven Systems, and Anisotropic Interactions. As is inevitable when covering a developing field, the narrative is not smooth. Some topics are treated in detail; in other cases the text simply notes the absence of a desirable experiment. The authors naturally emphasize their own interests and include some intensive theory sections.

The book convincingly makes the case that particle-resolved studies can provide information not obtainable in other ways. One example is the nature of the two-dimensional liquid–crystal freezing transition. Particle-resolved studies in both colloidal and plasma systems have elucidated the conditions under which freezing is a simple first-order transition, as in three dimensions, and those for which a more complex scenario applies—involving the appearance of an intermediate hexatic phase. Another complex and still not fully understood phenomenon that may be elucidated with particle-resolved studies is "laning": Like pedestrians on a busy sidewalk, two species of particles pushed in opposite directions tend to form lanes from an initially disordered state.

The stated aim of the book series is to address "graduate students and junior researchers as an introduction to new fields, but it should also be useful to experienced people who want to obtain a general idea on a certain topic or may consider a change of their field of research." In those aims I think the authors have been successful. *Complex Plasmas and Colloidal Dispersions* is not a textbook, although if supplemented by background reading, it could provide topics for an interesting graduate course. It is also not among the growing number of books that provide broad surveys of soft matter—the text is more focused than that. But, in part because of the extensive list of references, this book will certainly find a place on the shelves of experienced researchers as an up-to-date snapshot of a fast-developing area.

Peter N. Pusey
University of Edinburgh
Edinburgh, UK