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Editorial

Transport phenomena and phase transitions in soft and disordered systems

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Abstract The present special issue is devoted to the experimental, theoretical and computational studies of fundamental features in transport phenomena, structural and phase transitions in various soft and disordered systems (polymers, colloids, glasses, amorphous, crystalline, and composite materials) involved in macroscopically non-equilibrium processes (hydrodynamic flows; non-stationary deformations, heat and mass transfer and so on). Special attention is focused on a detailed microscopical study of the effects of internal structural and phase transformations on macroscopic physical properties and phenomena in the systems under study.

1 Introduction

Soft and disordered systems (glasses; multiphase materials; colloids; polymer; composites, biological tissues) are widespread in nature and actively used in modern engineering and bio-medical technologies. Because of the diversity and often the non-ergodic character of their internal structures and morphology, these systems are studied much weaker than highly ordered and solid materials. Very often they cannot be described based on the classical general methods of statistical physics and thermodynamics and their study requires the solution of many specific challenging problems. Undoubtedly, these problems are at the cutting edge of the modern science of condensed matter and statistical physics.

This theme issue deals with topical physical processes and phenomena of nonlinear, relaxational, and externally induced transport complicated by phase transformations and structural changes in various soft and disordered systems. Such processes are typical for materials sciences, applied physics, biophysics, medical physics; their detailed study is necessary for understanding and explanation of many natural phenomena as well as for development of new generations of modern high technologies and materials. The ability to control these processes through external influences (e.g. hydrodynamic currents, electromagnetic fields, temperature) allows the structure, behaviour, and properties of materials to be controlled and the optimal functioning of various devices based on them to be achieved. Regardless of the various transport processes and phase transformations in the considered soft and disordered materials, many of them can be described on the basis of unified theoretical models and approaches as well as computational methods, which allow studying the specificity of a particular problem and modeling the state of a material or system at different stages. The research articles presented in this theme issue are on the research front of transport phenomena and phase transitions in soft and disordered systems. They are divided into two groups according to the subject matter of transport phenomena and phase transitions:

1. Metastable liquids [1–9];
2. External impacts [10–17].

The first section is devoted to transport phenomena and phase transitions in metastable liquids. The growth of single spherical and ellipsoidal crystals in metastable liquids (supercooled melts and supersaturated solutions) is considered in Ref. [1]. The next papers [2,3] continue this study. Here the evolution of polydisperse ensembles of such crystals in binary supercooled melts and supersaturated solutions at the intermediate stage of phase transformation is studied. The transition of a metastable system from the intermediate to the final stage, and the system behaviour when coagulation of crystals occurs, is described in Ref. [4]. The next article [5] deals with the evolution of a two-phase region in the presence of heat exchange with the environment. The shape of crystals that can grow in such a two-phase zone is studied in Ref. [6]. The fol-

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lowing two articles [7,8] continue the study of pattern formation in metastable liquids. The first of them is devoted to computer simulation of periodic pattern formation using modified phase-field crystal models [7]. The second one develops an analytical approach to self-oscillatory pattern-forming crystal growth [8]. In the following paper, an approximate analytical solution of the kinetic and balance equations for the intense liquid boiling is constructed [9].

Magnetic fluids (macrodisperse magnetorheological fluids, or MRF, and nanodispersed ferrofluids—FF) and magnetic polymers are suspensions (composites) of fine magnetic particles in a host liquid or polymer medium. These systems attract considerable interest due to the rich set of unique physical properties, valuable for many engineers and bio-medical applications. One of the most interesting and practically important features of these systems is the ability to change their rheological properties, up to several orders of magnitudes under the action of an applied magnetic field (magnetorheological—MR effect). The paper [10] deals with the analysis of some important methodical problems which appear at the measurements of the MR effect in the MRFs, which can significantly affect the experimental results. Results of experimental and theoretical study of the strong MR effect in magnetopolymer compositions, a fast decrease of the system's rigidity while an increase of the amplitude of their shear deformation are presented in Ref. [11]. The paper [12] deals with the theoretical study of diffusion phenomena in FF, and the effect of internal chain-like structures on the diffusion coefficient of the nanoparticles. The results demonstrate that this coefficient is significantly anisotropic in the external field. Two papers [13,14] are devoted to physical phenomena in magnetic polymers and ferrofluids, which can be used in progressive bio-medical technologies. The magnetohyperthermic effect for cancer and other tumor therapy [13] and generation, by the oscillation field, of circulation flow in a channel with a ferrofluid drop, as a method of intensification of drug delivery in thrombosed blood vessels.

Two papers [15,16] are devoted to the influence of external hydrodynamic impacts. One of them gives exact solutions for MHD axisymmetric hybrid nanofluid flow and heat transfer over a permeable non-linear radially shrinking/stretching surface [15]. Another article focuses on pulsating hydromagnetic flow and heat transfer of Jeffrey ferro-nanofluid in a porous channel [16]. The last paper [17] is concerned with studies of the rubrene:MoO3 film through thermal evaporation technique. In this paper, the authors deposited the rubrene:MoO3 films (rubrene is a typical nonplanar-molecule organic semiconductor material) through thermal evaporation technique and investigated their surface morphology and electrical characteristics. They investigated its topography before and after annealing and found that the rubrene:MoO3 film after annealing is uniform and the surface is smooth compared to before annealing.

We believe that this issue would be interesting to a broad range of researchers in the field of materials physics. Namely, for theoretical physicists and chemists involved in transport phenomena and phase transitions, for those developing software, for scientists engaged in simulations, and, of course, for experimentalists from various fields of materials physics. The issue serves as a useful platform to share state-of-the-art trends and progress, search for new ideas, and reinforce research relationships.

Finally, we have to thank all the authors' teams for their excellent contributions to this thematic issue. We are also very grateful to all the reviewers for their comprehensive remarks, which have allowed us to provide a better presentation of the papers. And lastly, we should like to thank the EPJ ST publishing staff for their valuable partnership in putting together this theme issue.

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