Structure and Dynamics of Meso-Bio-Nano Systems

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Introduction

Biological matter, as well as any complex form of inanimate matter, consists of many different components linked by numerous, different interactions. Important efforts in deeping of our molecular-level understanding of biological systems and their dynamical behavior concern the origin, nature and evolution of various complex molecular systems and processes, as well as the emergence of new features, properties, functions in the systems with increasing their complexity. On the meso- and nanoscales, the physics and chemistry of biological macromolecules and atomic clusters typically deal with such behavior. Many examples of the emergence of qualitatively new features can be quoted, e.g. the development of new collective properties when going from small molecules to large clusters or the cluster aggregation on surfaces leading to the appearance of fractally shaped morphologies.[1] The fractal morphologies, being emerged in dynamical systems on the nanoscale, remain characteristic for many systems, including biological ones, at practically all larger scales, and are present in practically all living systems.

Methods

The project „Structure and dynamics of Meso-Bio-Nano systems" was carried out under the supervision of Prof. Dr. Andrey V. Solov'yov at the Frankfurt Institute for Advanced Studies. The project was devoted to investigation of structure formation and dynamics of animate and inanimate matter at the micro- and nanometer scales. There are many examples of complex many-body systems of micro- and nanometer scale size exhibiting

unique features, properties and functions. These systems may have very different natures and origins, e.g., atomic and molecular clusters and nanoparticles,[2,3] nanostructures,[4] biomolecules,[5] and mesoscopic systems.[6,7]

A detailed understanding of the structure and dynamics of these systems on the nanometer scale is a difficult and fundamental task, the solution of which is necessary in numerous applications of nano- and biotechnology, material science[8,9] and medicine.[10] Although mesoscopic, nano- and biomolecular systems differ in their nature and origin, a number of fundamental problems are common to all of them. Seeking answers to the fundamental questions is at the core of a field entitled Meso-Bio-Nano (MBN) Science which is a new interdisciplinary field that lies at the intersection of physics, chemistry, and biology.

Outlook

The MBN Science bundles up several traditional disciplines such as theoretical atomic and molecular physics, condensed matter physics, solid state physics, quantum physics, and chemistry, classical, quantum, and statistical mechanics, physical kinetics, molecular biology, biochemistry, and biophysics. A detailed theoretical description and complete understanding of MBN systems and phenomena with their involvement can only be achieved by utilizing a wide range of theoretical approaches and methods known from all these disciplines combined with advanced computational techniques and with the use of powerful computers.

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