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Preface

Patchy particles

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A broad range of self-organizing systems such as viruses, proteins, and clays are known to give rise to a wealth of structures by virtue of the asymmetry in their shapes and/or in their surface patterns. Learning from nature, the same concept is nowadays used in colloidal sciences to produce via self-assembly processes materials with specific or even desired symmetries and physical properties: the anisotropic particle–particle interactions that are responsible for the assembly of a wide range of mesoscopic architectures can originate from non-spherical shapes, surface moieties, induced dipole–dipole interactions, multipolar features and/or charge heterogeneities. Novel colloid-based units, characterized by anisotropic interactions, selective bonding mechanisms and limited valence, are able to assemble into a rich variety of structures at the nano- and micro-scale level via either self- or field-driven organization. Typically these fundamental building blocks, commonly referred to as 'patchy particles', are able to realize the highly directional and selective bonds needed to impart the assembly instructions to the single units via suitable particle designs.

In recent years, considerable progress has been made in tailoring the colloidal surface patterns during the experimental synthesis processes. However, the impressive potentialities offered by these new experimental achievements need information about how to optimize the design of patchy particles in order to realize self-assembled structures with desired properties. Thus, a close cooperation between experimentalists on one side and theoreticians and computer simulators on the other side is of great importance: suitable modeling of the experimental systems can provide guidelines on which features of the patchy units may favor the assembly of target mesoscopic structures.

Examples of recent developments in synthesizing particles with heterogeneously patterned surfaces includes not only patchy colloids in the proper sense, but for instance also (i) DNA-coated colloids with mobile DNA-linkers, (ii) polymer-based patchy systems characterized by the softness of the interactions as well as by the mobility of the patches, (iii) and multipolar and/or heterogeneously charged particles, possibly in the presence of external fields. In these systems competitive many-body effects, unexpected significant entropic contributions, particle internal degrees of freedom, or the competition between directional attractive and repulsive interactions play an important role, leading to a rich variety of assembly behaviors.

In order to give credit to some of the new developments in the field, a workshop, entitled 'Physics of colloidal particles with heterogeneously patterned surfaces', was organized at the Viennese Node of CECAM (DaCAM) from 24–27 September 2014, to bring together scientists from the theoretical, simulation and experimental communities. The many fruitful discussions between all the communities contributed to a deeper understanding of patchy systems and helped to address future aspects that might lead to more applied problems of technological relevance.

This special section of *Journal of Physics: Condensed Matter* collects research papers focused on the combination between shape anisotropy and directional interactions [1] as well as on dipolar and quadrupolar patchy units with few—either one [2] or two [3–5]—patches. Both numerical investigations on the collective behavior of these units [1–4] and experimental results on the synthesis and the assembly of patchy particles [5] are reported. The order of the papers in this special issue corresponds to that of the list of references here below.

Acknowledgments

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