Defect dynamics in 2D colloidal crystals

Master/Internship project

<u>Research Group</u>: Laura Rossi, Advanced Soft Matter, Chemical Engineering TUDelft

<u>Collaboration</u>: Dr. Janne-Mieke Meijer University of Konstanz/University of Amsterdam

The properties of crystalline materials are related to their building blocks as well as their structural defects. The shape of the building units plays an important role in determining the crystal symmetry; for instance, particles with a spherical interaction potential usually form close-packed configurations, while rod-like molecules tend to form liquid crystalline phases. Defects are structural imperfections that interrupt the crystal ordering and can influence the mechanical, electrical and optical properties of a material[1]. Defects can affect the properties of a material positively, for instance by strengthening its mechanical properties or enhancing the conductivity in a semiconductor. However they can also negatively affect a material, for instance by enhancing fatigue or softening nanocrystalline materials.

The study of defects at a single particle level is therefore crucial to design better materials. Despite their importance, we only have limited knowledge of how defects form, develop and interact with each other and what the consequences of such interactions are. This problem arises mainly because visualizing single defects in atomic crystals, while possible, is still experimentally challenging. One way to make the experiment more approachable is to study defect formation and dynamics in soft materials, materials made of colloidal particles. Colloids are particles with dimensions in the range 1-1000 nm. Like atoms and molecules, they diffuse due to thermal motion, and are therefore often used as models to study atomic and molecular phenomena[2]. Since they are larger and slower than atoms and molecules, we can use them to study defect dynamics at time and length scales much longer than in analogous molecular systems[3].

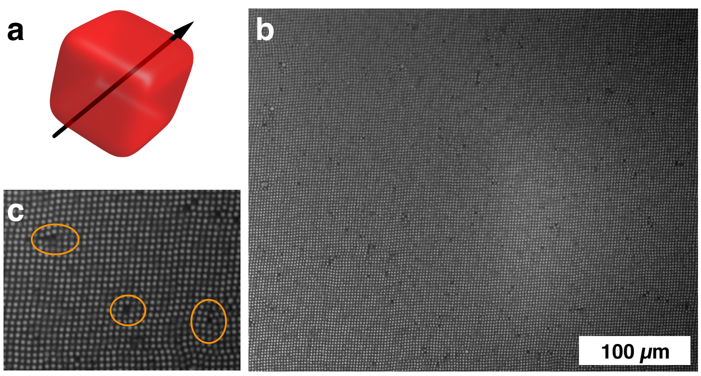

Figure 1 *(a) Model of a magnetic cubic particle with dipole moment orientation (black arrow). (b) The magnetic cubic particles in (a) readily form large 2D crystal structures in which various types of defects can be recognized as shown in the close-up image in panel (c). Here, a few defects are highlighted by orange circles.*

In this project, the student will study the presence of defects in a sample of attractive dipolar cubic particles recently developed in the group[4] (Figure 1a). Due to their strong dipolar interactions, the particles readily assemble into 2D

crystals that can be easily visualized with a simple optical microscope as shown in Figure 1b,c.
The student will have to design and build a magnetic setup to be used with the optical microscope currently available in the laboratory. The magnetic setup will be used to control the magnetic field and therefore the crystal structure formed by the magnetic particles. In collaboration with Janne-Mieke Meijer at the University of Konstanz, image analysis will be performed at the single particle level on different sets of crystals.

Depending on the length of the project the student can spend some time on the preparation of particles with tunable magnetic interactions[4] to study how the strength of the interparticle interactions can influence defect formation and dynamics.

1. D. Hull; D.J. Bacon. Introduction to Dislocations. Pergamon Press: 1984; Vol. 257.
2. Poon, W. C. K. (2004). Colloids as big atoms. *Science*, *304*(5672), 830–831.
3. Irvine, W. T. M., Vitelli, V., & Chaikin, P. M. (2010). Pleats in crystals on curved surfaces. *Nature*, *468*(7326), 947–951.
4. Rossi, L., Donaldson, J. G., Meijer, J.-M., Petukhov, A. V., Kleckner, D., Kantorovich, S. S., et al. (2018). Self-organization in dipolar cube fluids constrained by competing anisotropies. *Soft Matter*, *14*(7), 1080–1087.

For more information, please contact:

Dr. L. Rossi

Chemical Engineering Department
Van der Maasweg 9, Room D2.180
2629HZ Delft, the Netherlands

Email: L.Rossi@uva.nl
Phone: +31 (0)15 278 7980
Web: www.mycolloids.com