Orientational order of one-patch particles in a quasi-two-dimensional system

Yasutaka Iwashita* and Yasuyuki Kimura

Department of Physics, Kyushu University, Fukuoka, Japan

**iwashita@phys.kyushu-u.ac.jp*

A patchy colloidal particle is an ideal model system of anisotropic colloid due to its well-defined interaction anisotropy. Patchy particles exhibit novel positionally-ordered, i.e. crystalline, phases [1]. In addition, spherical patchy particles exhibit *purely orientationally-ordered phases* when closely-packed [2], which cannot be attained with shape anisotropy. Orientational order is expected to realise unique material properties compared with those by positional order, as known for magnetic or dielectric properties by the orientational order of dipoles in atomic / molecular condensed matter. However, the great variety of the phases in patchy particles often results in the degeneracy of the ground states, and a system falls in a metastable state or several metastable states coexist in a system.

We study the orientational order of closely-packed one-patch particles in a quasi-two-dimensional system between flat substrates. By comparing the experiment and Monte-Carlo simulation results, we found that the degeneracy of orientationally-ordered state is resolved by the lower-dimensionality of the system: A commensurate state(s) with the system geometry and boundary conditions is selected from the (meta)stable options in the corresponding bulk system [2]. In addition, even a unique order appear when all of the states in bulk are incommensurate with the quasi-two-dimensional system. Our study opens a new route for realizing and controlling the mesoscopic order in patchy particles. In addition, the ordering mechanism would be applicable to various other systems where mesoscopic objects are confined in a thin, two-dimensional space.

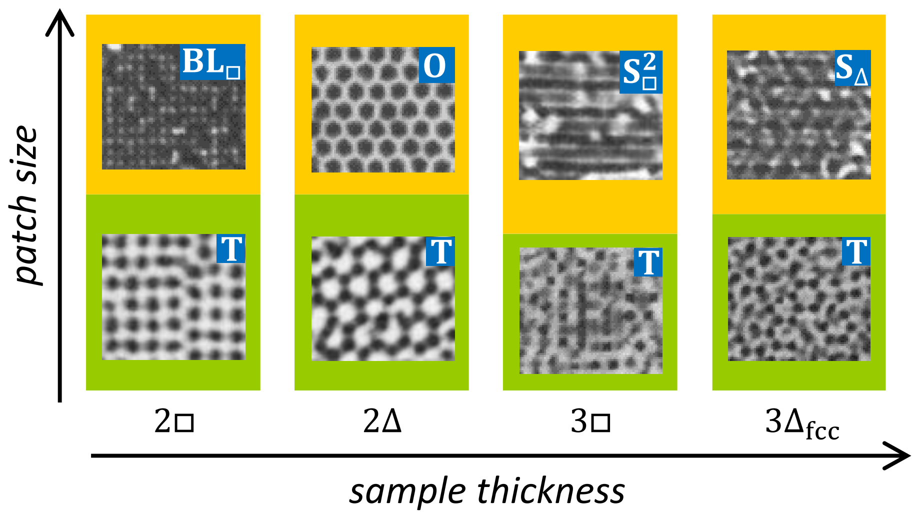

Figure 1 Schematic phase diagram of orientationally-ordered state in one-patch particles, with typical optical microscopy images. The phases are: T; tetrahedron tetramer, BL; bilayer sheet, O; octahedral hexamer, and S; stripe structure.

[1] e.g., Q. Chen *et al.*, *Nature*, **469**, 381 (2011); D.Z. Rocklin & X. Mao, *Soft Matter*, **10**, 7569 (2014).
[2] e.g., Z. Preisler *et al.*, *Soft Matter*, **10**, 5121 (2014); Y. Iwashita & Y. Kimura, *Soft Matter*, **10**, 7170 (2014).