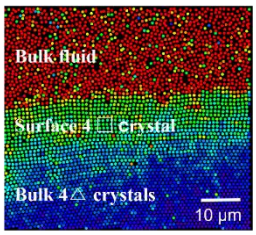
中央大學物理學系

Department of Physics, National Central University

Premelting-like phenomena on the surfaces of colloidal crystals and glasses

Prof. Yilong Han 韓一龍

Department of Physics, Hong Kong University of Science and Technology (HKUST), Hong Kong



Time: 09:00-10:00, Jan 10(Fri), 2025

Place: S4-625

Abstract:

Analogous to premelting and prefreezing, are there other similar surface phenomena as a phase-transition precursor? Can premelting be generalized from crystals to amorphous solids? These questions could be asked and studied decades ago, but surprisingly have not been discussed in literature. We study these blind spots in material science using colloids with temperature-sensitive attractions.

We observe crystal surface premelting at the single-particle level for the first time [1] and find that monolayer and bilayer crystals exhibit distinct premelting and melting behaviors in experiment [1] and simulation [2]. Analogous to premelting and prefreezing, we propose the third type of surface wetting phenomenon as a phase-transition precursor and named it as pre-solid-solid transition, i.e. a surface polymorphic crystal formed before reaching the solid-solid transition [3]. We confirm it in colloid experiment (figure) and simulation [3], and attribute it to the lower-energy coherent interface. This thermal equilibrium behavior can also exist in nonequilibrium processes of melting, crystallization, and polycrystal annealing [3,4]. We suggested several atomic/molecular polymorphic crystals which may exhibit the pre-solid-solid transition.

Glass melting lacks experiment at the single-particle level; Ultrastable glass has not been fabricated in colloids; Whether a glass can exhibit premelting has not been explored. Our colloidal experiments address these three challenges and unveil two surface layers [5]. As approaching the transition points, the thicknesses of the premelted surface liquid and pre-sollid-solid surface crystal all grow in power laws as predicted in premelting theory [5]. Similar behavior has been observed in polymer and molecular glasses, but it is called surface mobile layer instead of premelting.

References

[1]B. Li, F. Wang, D. Zhou, Y. Peng, R. Ni, and Y. Han, Nature 531, 485 (2016)

[2]X. Wang, B. Li, X. Xu, and Y. Han, Soft Matter 17, 688 (2021)

[3]X. Wang, B. Li, M. Li, and Y. Han, Nat. Phys. 19, 700-705 (2023)

[4]M. Li, Z. Xu, Q. Zhang, W. Li, Y. Zhang, and Y. Han, Phys. Rev. Lett. 133, 248202 (2024)

[5]Q. Zhang, W. Li, K. Qiao, and Y. Han, Sci. Adv. 9, eadf1101 (2023)