Homogenous Nucleation in the Melting of Superheated Colloidal Crystals

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Ziren Wang*, Feng Wang, Yi Peng, Yilong Han

Department of Physics, Hong Kong University of Science and Technology, Hong Kong

***Email of Presenting Author: ziren@ust.hk**

The study of nucleation and growth processes are of central importance in phase transition, but kinetics of these processes is difficult to predict and measure, especially for homogeneous melting. Here we focused a beam of light to locally superheat and melt the interior of thermal-sensitive colloidal crystals and investigated the homogenous melting with single-particle dynamics by video microscopy for the first time [1]. We found that the precursors before liquid nuclei form are local particle-exchange loops rather than any defects. The measured critical nucleus size and the incubation time as a function of the degree of superheating agree well with the classical nucleation theory at the weak superheating regime. At strong superheating, however, the nucleation behaviors deviate from the classical nucleation theory, mainly because of the coalescence of nuclei. The measured growth rates of post-critical nuclei showed that the Wilson-Frenkel law for crystallization needs to be extended to a more generalized form for both crystallization and melting. At strong superheating, the nucleus growth rate was greatly enhanced by multimer attachment which is overlooked in classical nucleation theory. Furthermore, we measured the nucleus shape evolution, nuclei coalescence and the superheat limit.

Reference:

[1] Ziren Wang, Feng Wang, Yi Peng, Zhongyu Zheng and Yilong Han, Imaging the homogenous nucleation during the melting of superheated colloidal, Science 338, 87 (2012)