Structural identification of photonic balls using structural color patterns

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Spherical colloidal clusters ("photonic balls") (Figure (a)) are formed by the self-assembly of monodisperse colloidal particles within shrinking droplets. Photonic balls exhibit a variety of particle arrangements, including icosahedral, decahedral, and layered face-centered cubic (FCC) crystalline domains [1], and display characteristic structural color patterns such as triangular and teardrop shapes depending on the internal structures [2,3]. Structural color evolution during droplet shrinkage has therefore been expected to serve as an indicator of structural formation [3,4]. However, the interpretation of optical patterns in terms of specific internal structures remains ambiguous, particularly for orientation-dependent reflection geometries.

In this study, we propose an optical approach using different illumination conditions for structural identification of photonic balls formed from shrinking W/O/W double-emulsion droplets. By using bright-field, dark-field, and transmission imaging (Figure (b–d)), we systematically examine how reflection patterns depend on both internal structures and viewing direction. In particular, dark-field illumination enables detection of off-axis reflections that are difficult to observe under conventional bright-field conditions.

We demonstrate that characteristic reflection patterns, such as triangular- or teardrop-shaped features, provide optical fingerprints associated with distinct structural motifs. While the observed patterns depend on droplet orientation, the different illumination conditions enable more reliable structural interpretation across different viewing conditions.

This optical approach provides a practical method for structural identification of photonic balls and offers a framework for more precise *in situ* investigation of self-assembly pathways in confined colloidal systems.

Keywords:
photonic ball, colloidal crystal, structural color

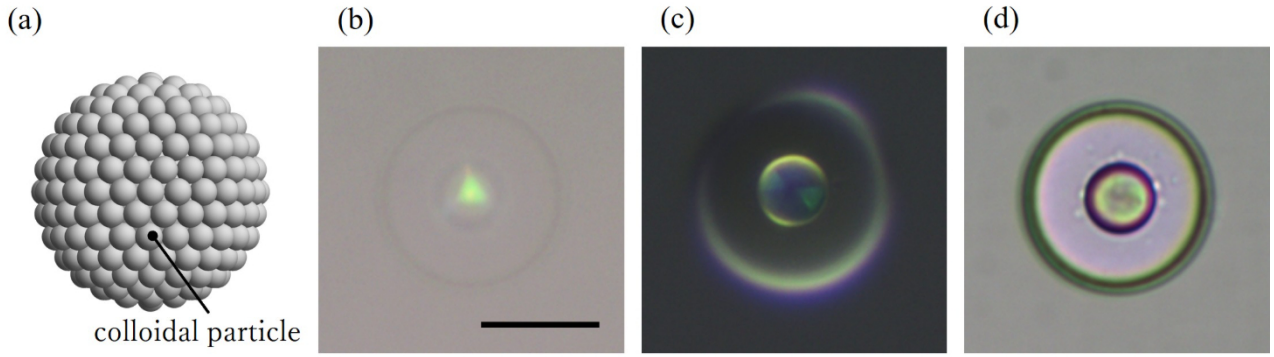

Figure (a) Schematic illustration of a photonic ball. Optical micrographs of a photonic ball during the formation process observed under (b) bright-field illumination, (c) dark-field illumination, and (d) transmission illumination. The scale bar represents 20 μm.

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