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Quantitative metrics for assessing positional and orientational order in colloidal crystals

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Structural control in colloidal films has potential benefits for photonics, material templating, and in fundamental studies of phase transitions. Although there are numerous self-assembly techniques to prepare colloidal crystals, there is great variability in the methods used to characterize order and disorder in these materials. In this work, we take on the task of assessing different kinds of structural order from two-dimensional microscopy images of colloidal crystals produced by many common methods (and by many different research groups) including spin-coating, dip-coating, convective assembly, electrophoretic assembly, and sedimentation. To do this, we use a suite of analysis methods that includes measures for both positional and orientational orders. Our benchmarks are two-dimensional lattices that we simulated with different degrees of controlled disorder. We find that translational measures are adequate for characterizing small deviations from perfect order, while orientational measures are more informative for polycrystalline and highly disordered crystals. Our analysis codes are freely available for others to use, and they offer a convenient and unified strategy for comparing structural order among different colloidal crystals.

Primary authors: YETHIRAJ, Anand (Memorial University); PODUSKA, Kristin (Memorial University of Newfoundland); BAGHERI, Payam (Memorial University of Newfoundland)

Co-author: ALMUDALLAL, Ahmad (Memorial University of Newfoundland)

Presenter: PODUSKA, Kristin (Memorial University of Newfoundland)

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