**Fluid-to-solid Transition of Hard Regular Polygons**

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**Abstract**

The fluid-to-solid transition of two-dimensional systems is a fundamental problem in condensed matter physics that requires a large amount of computational power. We used the Titan supercomputer to perform massively parallel Monte Carlo simulations of up to one million hard polygons (n=3 to 14) near the melting transition. We find that regular polygons with seven or more edges behave like hard disks and melt continuously from a solid to a hexatic fluid and then undergo a first-order transition from the hexatic phase to the fluid phase. Strong directional entropic forces align polygons with fewer than seven edges and improve local ordering. Triangles, squares, and hexagons exhibit a KTHNY-type continuous transition between fluid and hexatic, tetratic, and hexatic phases, respectively, and a continuous transition from the appropriate x-atic to the solid. In contrast, pentagons and plane- filling 4-fold pentilles display a one-step first-order melting of the solid to the fluid with no intermediate phase. The thirteen studied systems thus comprise examples of three distinct two-dimensional melting scenarios.