Study of Two-dimensional Melting in a System of Small Magnets

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The effort to understand the microscopic mechanism of melting has intrigued scientists for more than 100 years, but many questions about melting mechanisms remain to be answered. The aim of our work is to study configurational and melting properties of finite number (64) of 6 mm sized disc magnets moving on an air layer produced by an air table to imitate two-dimensional (2D) crystal and to compare experimental results with molecular dynamics simulation. Magnetic moments of the magnets in our experiment are oriented perpendicularly to the layer so that magnets repell each other by dipolar magnetic interaction. By changing the velocity of the air current blown to the air table we influenced temperature calculated through particle velocities. The movement of particles was recorded with a webcam and we created scripts in Matlab to analyze videos and to determine particle trajectories, velocity distribution, Voronoi diagrams of next neighbors and distributions of shape factor and angles in Delaunay triangulation. We used the Verlett algorithm for molecular dynamics simulation in Matlab and we compared the results of the computer simulation with the experimental system. Our results show, that a 2D hexagonal lattice forms at low temperature while with increasing temperature we can observe a change of the lattice symmetry from hexagonal to square. The dependence of averaged number density of defects on the temperature exhibits sudden increase indicating transition to the liquid phase. Particle trajectories in this phase reveal the surprising square shell structure with larger intra-shell diffusion and less probable inter-shell hopping.

Awards Won:

Second Award of $2,000