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How crystals melt and glasses form in two dimensions

Georg Maret

Fachbereich Physik, Universität Konstanz

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The nanoscopic processes responsible for melting of crystals, crystallisation and glass transition belong to the most important and largely open issues in solid state physics. Suspensions of microscopic particles (so-called colloids) at high packing densities have turned out ideal model systems to study the underlying structural and dynamic changes with high accuracy. This is because individual colloids can easily be tracked at all relevant time and length scales by real time video microscopy. This talk focuses on a two dimensional system of superparamagnetic colloids with knob-tuneable pair interactions free floating near a planar air-water interface. Using monodisperse such particles, large 2D hexagonal crystals can be made and their melting quantitatively verifies the 2D melting scenario predicted by Kosterlitz, Thouless, Halperin, Nelson and Young. Binary mixtures form 2D-fluids or -glasses and provide detailed information about the mechanism driving the structural arrest near the glass transition; it involves dynamic heterogeneities correlated with structural heterogeneities caused by different types of nanocrystallites responsible for a widely varying energy landscape.