Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **3418** Type: **Invited Speaker / Conférencier(ère) invité(e)**

(I) Emergence of discrete relative ordering in coupled XY models

Tuesday 7 June 2022 16:15 (30 minutes)

Many two-dimensional physical systems, ranging from atomic-molecular condensates to low-dimensional superconductors and liquid crystal films, are described by coupled XY models. The interplay of topology and competing interactions in these XY systems drives new kinds of emergent behavior relevant in both quantum and classical settings. Such coupled U(1) systems further introduce rich physics, bringing topology into contact with fractionalization and deconfinement. In this talk, I will focus on the realization of these systems in a liquid crystal setting, where the theoretical description of 2D crystallization involves the binding of topological defects, accompanied by smooth thermodynamic transitions. However, the isotropic liquid crystal 54COOBC thin films are found to solidify via an intermediate "mystery"phase associated with a sharp specific-heat anomaly.

I will show that this hidden-order phase can be understood as the relative ordering of the nematic and hexatic molecular degrees of freedom. This insight comes from the finite-temperature phase diagram of a minimalist hexatic-nematic XY model obtained through extensive large-scale Monte-Carlo simulations. A small region of composite three-state Potts order above the vortex binding transition is identified; this phase is characterized by relative hexatic-nematic ordering though both variables are disordered. I will show that the Potts order results from a confinement of fractional vortices into extended nematic defects and discuss the broader implications of fractional vortices and composite ordering in the wider class of coupled XY condensates, relevant to both soft and hard condensed matter fields.

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Session Classification: T4-7 Fluctuations and Disorder in Condensed Matter (DCMMP) | Fluctuations et désordre en matière condensée (DPMCM)

Track Classification: Symposia Day (Tues. June 7) / Journée de symposiums (mardi, le 7 juin): Symposia Day (DCMMP) - Fluctuations and Disorder in Condensed Matter