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Exploring Berezinskii-Kosterlitz-Thouless physics with cold gases

The types of order present in the low-temperature states of matter are fundamentally dependent on the dimensionality of physical systems.
Generally, highly ordered states are more robust in higher dimensions, while thermal and quantum fluctuations, which favor disordered states, play a more important role in lower dimensions.
In this set of lectures, which will complement the preceding colloquium, we will investigate the case of two-dimensional Bose fluids of light or atoms, for which thermal fluctuations prevent the occurrence of Bose-Einstein condensation in an infinite, uniform system, but are not strong enough to suppress superfluidity. We will explore the mechanism discovered by Berezinskii, Kosterlitz and Thouless, which is a "topological phase transition" driven by point-like defects, quantized vortices in the present case. We will also discuss other topology-related effects in these systems, in relation with the creation of artificial gauge fields and quantum-Hall type phenomena.