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Accessing unconventional quantum phenomena using synthetic gauge fields

QI ZHOU, The Chinese University of Hong Kong

The recent realization of synthetic gauge fields, using either the Raman scheme or shaken lattices, provides physicists a new means to control ultracold atoms. This talk will address how to use such synthetic gauge fields to access and explore a variety of unconventional quantum phenomena that are difficult to reach in other systems. I will first discuss a quartic dispersion that leads to the absence of a condensate even at zero temperature in two dimensions. This offers physicists an ideal simulator of the quantum Lifshitz model for realizing a two-dimensional algebraic quantum liquid and directly visualizing the deconfinement transition of vortices. I will then discuss schemes for studying a number of topological phenomena in ultracold atoms, such as topological flat bands, quantum anomalous hall effect, and Weyl points in a band structure. Thanks to photon-assisted band hybridizations in shaken lattices, rich topological phenomena naturally emerge without resorting to extra external fields. These examples compose an overture to a new era that will be brought by the interplay between synthetic gauge fields and the highly tunable ultracold atoms.