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Quantum Hall States with Symmetry-enriched Edge Modes in Multicomponent Bose Gases

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While atomic gases are charge neutral, a synthetic magnetic field can be induced in such gases by rotating the system or optically dressing atoms. A sufficiently high synthetic field for ultracold atoms is expected to offer interesting analogues of quantum Hall states with a rich diversity of statistics and spins of constituent particles. For two-component Bose gases, we present numerical evidences for a bosonic version of an integer quantum Hall state at the filling factor 2. This state is an example of a symmetry-protected topological state, featuring counterpropagating charge and spin modes at the edge which are protected by the particle-number conservation. Furthermore, by generalizing this state for n-component Bose gases, we construct fractional quantum Hall states at the filling factor n/(n-1). These states show a set of charge modes and n-1 sets of spin modes counterpropagating at the edge when the particle number is conserved. In contrast to the n=2 case, the edge modes are symmetry-enriched in the sense that the n-2 sets of spin modes are robust against the breaking of the symmetry. We present a numerical evidence for the symmetry-enriched edge modes for n=3.