Hidden long-range order in a spin-orbit coupled two-dimensional Bose gas

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A spin-orbit-coupled two-dimensional Bose gas is shown to simultaneously possess quasi- and true long-range order in the total and relative phase sectors, respectively [1]. The total phase undergoes a Berenzinskii-Kosterlitz- Thouless transition to a low-temperature phase with quasi-long-range order, as expected for a two-dimensional quantum gas. Additionally, the relative phase undergoes an Ising-type transition building up true long-range order, which is induced by the anisotropic spin-orbit coupling in combination with spin-dependent particle- particle interactions. Based on the Bogoliubov approach, expressions for the total- and relative-phase fluctuations are derived analytically for the low-temperature regime. Numerical simulations of the stochastic projected Gross-Pitaevskii equation give a good agreement with the analytical predictions.

[1] S.-W. Su, I-K. Liu, S.-C. Gou, R. Liao, O. Fialko, J. Brand, Phys. Rev. A **95**, 053629 (2017).