Spontaneous formation of topological defects in ultra-cold gases

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Abstract:

The formation of topological defects in symmetry breaking phase transitions is commonplace in a wide range of physical systems. The well-known Kibble-Zurek mechanism is a universal theory that estimates the scaling law for the density of topological defects in both quantum and classical phase transitions [1,2]. It has been applied to a wide range of systems covering classical and quantum physics, from liquid crystals through to cosmological scenarios. However while the Kibble-Zurek prediction for the scaling of defect density has been shown theoretically a number of times, it has yet to be conclusively observed in an experiment. Recent experiments in quantum gases have reported the observation of spontaneous formation of topological defects in spin-one [3] and single component [4] Bose-Einstein condensates. The cleanness and flexibility of ultra-cold gas systems raises the possibility of experimentally measuring the scaling of defect density predicted by the Kibble-Zurek mechanism for the first time.

In this paper we describe our work outlining two experimental systems for observing a Kibble-Zurek scenario in ultra-cold gases. The first is in the thermal Bose-Einstein condensation transition in a weak, oblate harmonic trap. The second is a novel Kibble-Zurek mechanism in a coupled, two component Bose-Einstein condensate in an elongated trap undergoing a controlled quantum phase transition between miscibility and immiscibility.

References:

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