Decay of sound waves in ring-shaped Bose–Einstein condensates

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We explore the viability of a rotation sensing scheme in which long-wavelength standing waves are excited in the density of a ring-shaped Bose–Einstein condensate. If the observer is in a frame rotating relative to the condensate, the standing wave will be seen to precess at a rate proportional to the rotation [1]. We have experimentally demonstrated a proof-of-principle rotation measurement using this scheme. However, we find that the excited sound waves rapidly decay, leading to poor rotation sensing precision compared to existing technologies. We use classical field simulations to model our system at finite temperature, allowing us to probe this decay behaviour in detail. The simulations reveal a remarkably rich variety of damping phenomena that take place in our system, with nontrivial dependence on the temperature of the gas and the amplitude of the excited standing wave. We identify an interplay between two distinct decay mechanisms: temperature-dependent Landau damping and amplitude-dependent four-wave mixing. The distinction is mostly clearly visible for high amplitude excitations, when a dynamical crossover between the two mechanisms is observed, signalled by a change in the exponential decay rate of the excited mode. Our theoretical results suggest that the rotation sensing precision is most significantly improved in the limit of low temperature and low amplitudes, when both damping mechanisms are minimised.

[1] G. E. Marti, R. Olf and D. M. Stamper-Kurn, Phys. Rev. A. **91**, 013602 (2015).