Precursor phenomena of nucleations of quantized vortices in the presence of a uniformly moving obstacle in Bose-Einstein condensates

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The motion of the macroscopic object above a critical velocity in superfluids triggers breakdown of superfluidity due to nucleations of quantized vortices. Many experimental[1] and theoretical[2] studies about these phenomena have been done. However, the underlying mechanism of the nucleation of the vortices are still unclear.
We investigate the stability of Bose-Einstein condensates confined in a finite size torus with a uniformly moving Gaussian potential by solving the Gross-Pitaevskii and the Bogoliubov equations. We show that the system does not exhibit both the Landau and the dynamical instability. The first excited energy(energy gap) obeys a scaling law near the critical velocity. This means that dynamical critical phenomena occur in this system. We also find the enhancement of low-energy dynamical local density fluctuations near the critical velocity. These phenomena can be regarded as precursor phenomena of the nucleation of quantized vortices.

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