

Simulating matter-wave lensing of BECs in 2D and 3D

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The extended microgravity conditions granted by cold-atom experiments in space enable free-evolution times of many seconds, which can be exploited in high-precision measurements based on atom interferometry. However, in order to reach such long evolution times, it is necessary to employ ultracold atoms combined with matter-wave lensing techniques, and a detailed modeling is required.

We present full 3D numerical simulations performed on a GPU cluster of BECs freely expanding for tens of seconds and compare them to effectively 1D and 2D simulations for spherically- and axially-symmetric configurations. A particularly interesting case arises when the lensing potential is applied after the BEC has expanded sufficiently so that the diffraction effects associated with the finite size of the BEC dominate over the mean-field interaction. This enables the validation of our simulations in a regime where the time-dependent Thomas-Fermi approximation fails to provide an accurate description of the dynamics. Finally, as an application of our methods for axially-symmetric configurations, additional features that arise in the anisotropic case will be discussed as well.

Keywords: BEC, matter-wave lensing, delta-kick collimation, numerical simulations

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