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Multiple lensing methods of ultracold atomic and molecular ensembles

We present two different methods to collimate atomic and molecular ultracold ensembles. The idea of both methods is to limit the expansion rate of the considered ensemble while preserving its phase space density [1].

The first method uses time-averaged potentials to form an all-optical matter- wave lens [2]. By using 39K instead of 87Rb in the same apparatus, magnetic Feshbach resonances are implemented to change the atomic scattering length. This procedure allows to even further reduce the final temperature of the ensemble by lowering the mean field energy.

The second method is the Delta-Kick Collimation [1] generalized to molecular ensembles. We consider both the condensed and the thermal regime. A Delta-Kick Collimation procedure allows us to divide the expansion energy of a released molecular ensemble by at least a factor of 90. In the best case, we can even divide the expansion energy by a factor of 10^4. Finally, this procedure can also be used to measure the intermolecular scattering length with a high accuracy. This work may provide a useful tool for preparing collimated binary mixtures for atom interferometry.

[1] H. Ammann and N. Christensen, Delta Kick Cooling: A New Method for Cooling Atoms, Phys. Rev. Lett. 78, 2088 (1997)
[2] H. Albers, R. Corgier, A. Herbst, et al., All-optical matter-wave lens using time-averaged potentials, Commun Phys 5, 60 (2022)

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