Coherent splitting and recombination of bright solitary matter waves

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We report on the controlled creation, splitting and recombination of bright solitary matter waves formed from Bose-Einstein condensates of ^{85}Rb atoms. These solitons propagate over macroscopic distances without visible dispersion and are exceptionally long-lived; observable for longer than 20 seconds. The splitting proportion between the daughter solitons is fully tunable with the incident soliton kinetic energy, barrier width and barrier height, in good agreement with 1-D and 3-D Gross-Pitaevskii simulations.

We observe that the transmitted daughter soliton has a larger centre of mass kinetic energy than the reflected daughter soliton, indicating that the splitting is a velocity filtering process. Despite this, we are able to reach a regime where the kinetic energy difference is sufficiently suppressed to enable coherent recombination of the daughter solitons.

We aim to utilise this scheme for soliton-based interferometry in a variety of configurations. Of particular interest is a ring geometry for Sagnac interferometry, which we intend to implement using a 2-D AOM painted ring potential.

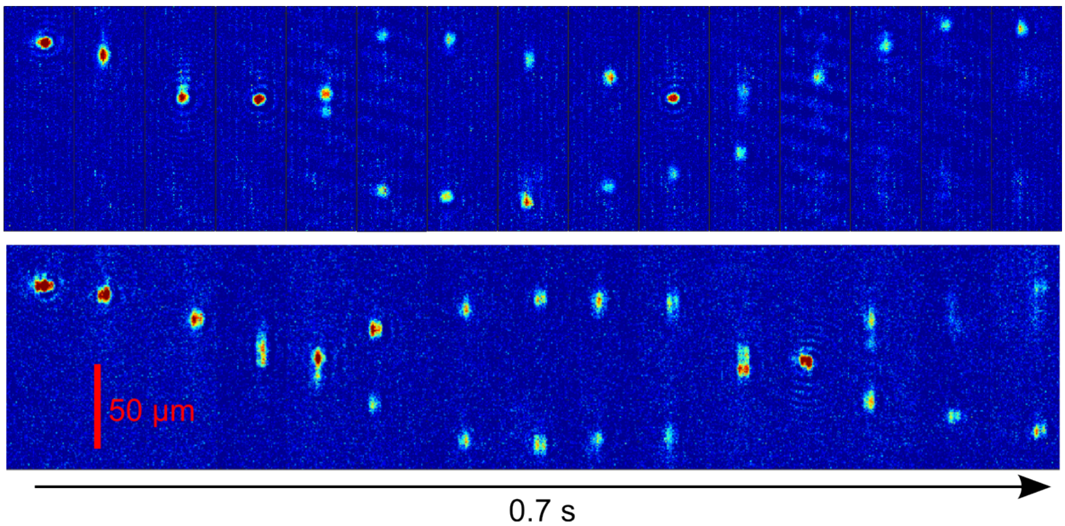

Fig. 1: A series of absorption images taken at 50 ms intervals showing splitting of a soliton into two daughter solitons by a narrow, repulsive barrier; along with the subsequent interaction of the daughter solitons with the barrier. The upper series demonstrates an off-centre barrier case where velocity selection dominates causing the final population to be almost entirely above the barrier. In the lower sequence we observe the impact of soliton-soliton interactions dominating velocity filtering and enabling recombination, resulting in significant population below the barrier.