Bright atomic solitons for repulsive interaction?

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Nonlinearity is one of the most prominent features of atomic Bose-Einstein condensates (BECs). The experimental availability of BECs thus opens the door to the exploration of the field of nonlinear atom optics, just as the invention of the laser in the 1960s led to the investigation of nonlinear optical effects. Our goal is to observe nonlinear atom optical effects using a ^{87}Rb condensate. In particular, we focus on the creation of a localized matter wave packet that propagates without spreading: a bright atomic soliton [1].

Solitons come in two flavours: Dark solitons corresponding to local dips in the density distribution of the BEC have already been observed [2, 3]. They are natural solutions to the 1D-Gross-Pitaevskii equation for repulsive atom-atom interaction. A bright atomic soliton, on the other hand, is a solution where the whole condensate moves in one dimension as a spatially localized wave packet. In this case, an attractive interaction is required to balance the free space dispersion. Although dark solitons are very interesting from a fundamental point of view, bright solitons seem to be a better candidate for the use in atom optics applications such as atom interferometry. However, the restriction to attractive interactions also imposes limitations on the size of the available condensates.

We will discuss in detail an alternative approach to the realization of a bright atomic soliton. It relies on the possibility to tailor the dispersion relation of atomic matter waves utilizing a weak one-dimensional periodic potential. This approach is analog to "dispersion management" in nonlinear photon optics, where a spatial periodic modulation of the refractive index leads to anomalous dispersion. For matter waves, anomalous dispersion can be characterized by a negative effective mass, allowing for the creation of bright solitons even for repulsive interaction.

We report on the creation of a BEC in ^{87}Rb in a magnetic TOP trap. The condensate is loaded into a far detuned optical dipole trap to allow for free propagation in one dimension while maintaining transversal confinement. The one-dimensional dynamics of the condensate is manipulated by applying a periodic light shift potential. We present the latest results of our experiment towards the implementation of dispersion management and the creation of bright atomic solitons.

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