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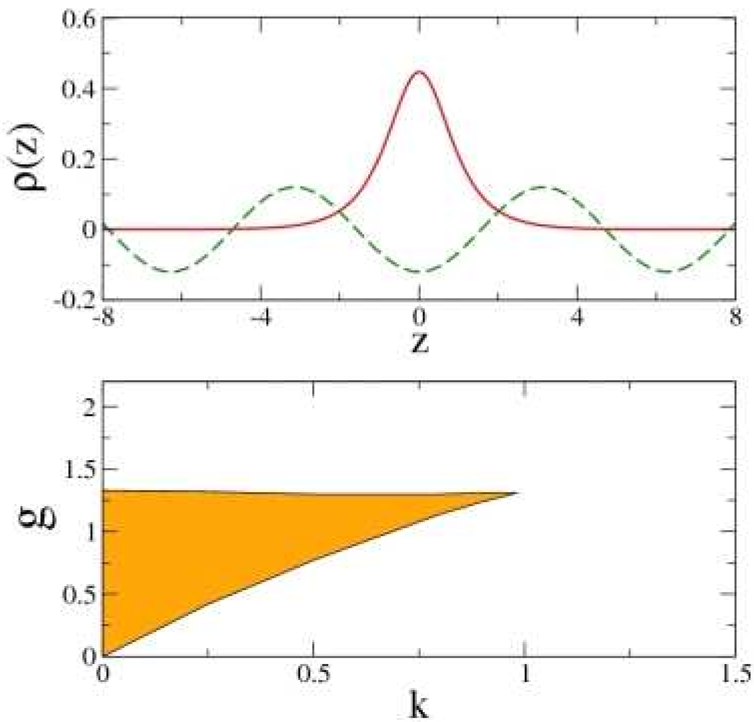
Bose-Einstein condensates in nonlinear lattices

Can Bose-Einstein condensates with a spatially periodic scattering length support bright solitons?



(http://images.iop.org/objects/jio/labtalk/3/3/18/Image1.jpg)
Predicting stable bright solitons. (http://images.iop.org/objects/jio/labtalk/3/3/18/Image1.jpg)

Two researchers, from the Universities of Padua and Tel Aviv, have theoretically investigated dilute Bose-Einstein condensates made of ultracold atoms of alkali metals, with the scattering length of atomic collisions, which periodically changes its sign along the axial direction. This configuration, called a nonlinear lattice (NL) because it produces a spatially periodic nonlinear strength of the mean-field potential of atoms, can be created by means of available experimental techniques based on the Feshbach resonance, which, in turn, may be controlled by spatially nonuniform magnetic or laser fields.

In their work (published in 2012 *J. Phys. B: At. Mol. Opt. Phys.* **45** 055302 (http://iopscience.iop.org/0953-4075/45/5/055302)), the two scientists have predicted stable bright solitons supported in the atomic Bose-Einstein condensates by the NLs. In the upper panel of the figure, the axial density profile of a stable bright soliton is shown by the red solid line, while the green sinusoidal line represents the periodic modulation function of the local nonlinearity. The stability domain (the orange region in the lower panel) for these bright solitons is drawn in the plane of the NL strength g and wavenumber k.

Moreover, the research duo has produced numerical simulations that show that a kick applied to the bright soliton either leaves it pinned or, eventually, destroys it. The critical size of the kick which destroys the soliton is proportional to the strength of the NL, provided that the strength is large enough.

The authors have provided an explanation to this finding. On the other hand, a kick, if applied to the wave packet created above the collapse threshold, may help it to shed off the excess norm and thus stabilize itself against the collapse. A related dynamical effect, which demonstrates the difference of the NLs from linear lattices, is that small-amplitude waves, emitted by wave packets relaxing into solitons, freely propagate in the system.

More details (http://iopscience.iop.org/0953-4075/45/5/055302) of the authors’ work are published in *Journal of Physics B: Atomic, Molecular and Optical Physics.*

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