Dynamics of matter waves within a soft optical lattice

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Optical lattices are now widely used in cold atom and molecule physics research. It is generally accepted that the lattice is not deformed (in some sense, rigid) even after loading atoms into the cross region of two counterpropagating optical fields. However, in explaining asymmetric matter wave diffraction of two counterpropagating optical fields with unequal intensities,we found that the optical lattice was actually deformed due to local field effect [1], i,e., optical scattering by the condensate, which was previously ignored due to the fact that the condensate refraction index is nearly same as vacuum refraction index, leads to imperfect interference fringe of two counterpropagating coherent optical fields. We call this kind of optical lattices as soft lattices. A further analysis shows that the local field effect induces a dipolar deform potential, a long-range interaction and a spatially-modulated short-range self-interaction for the condensate, thus even without direct s-wave scattering interaction between two atoms, matter wave solitons can be generated. More interesting, optical solitons can also be formed. The influence of soft optical lattices on precision measurement, such as optical lattice atomic clocks, will be briefly discussed.

References:

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