Emerging novel phases of Bose-Einstein Condensate for various topology

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Synopsis: In this work, we realize the soliton's negative mass regime, when a Bose-Einstein condensate is subjected to a harmonic confinement. We also discuss that this system is favorable for the formation of a bound state when an additional species is considered. When a time modulated optical lattice potential is introduced, the sinusoidal lattice modes lead to the generation of nonlinear resonances. A classical dynamical phase transition is also identified in this case through a superfluid to the insulating phase transition.

We study Bose-Einstein condensate (BEC) for different geometrical confinement through mean-field description. Interestingly we observe several novel consequences arising from the interplay of confinement and interaction. When BEC is subjected to the harmonic confinement, we observe that the solitonic excitations in the system initiates generation of negative mass regime, as is shown in Fig.1. We also realize that this geometry is favorable for bound state formation when we introduce another species of BEC. Introduction of a time modulated optical lattice potential in the system, drastically changes the dynamics of the system. In this case, we observe the emergence of nonlinear resonances and classical dynamical phase transition, through the density distribution and energy spectrum. When the harmonic trap is switched off, the system undergoes a nonlinear compression for the static OL potential. In a harmonic trap, the center of mass undergoes periodic oscillation (Fig. 2a), as a consequence of Kohn mode. When the harmonic trap is made time dependent, it breaks the periodicity and the center of mass no longer obeys the Kohn theorem, as can be seen from Fig.2b. Possible application of such geometry to information storage and retrieval is also discussed.

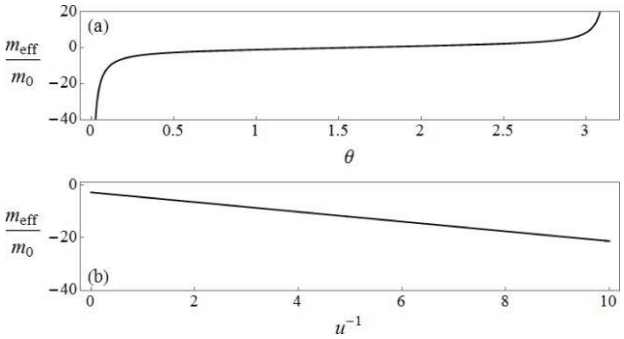

Fig.1: The effective mass profile (m_{eff}) is shown as a function of (a) Mach angle (θ), showing negative mass regime at the low momenta regime. (b) Shows the negative mass regime as a function of inverse of the soiton's velocity (u^{-1}).

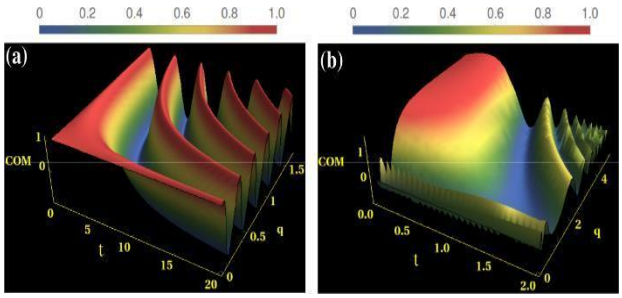

Fig.2: (a) The center of mass profile is depicted in presence of a regular harmonic confinement, showing that the COM oscillates with trap frequency. (b) The COM profile described by the Bessel function, where the harmonic trap varies exponentially with time.

References

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