Hot topic presentation

Investigating Quantum Diffusion and Localization in Atom-Optics Kicked Rotor Systems

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The quantum kicked rotor (QKR) model serves as a fundamental platform for exploring dynamical localization due to quantum chaos and transport phenomena in quantum systems[1]. By subjecting particles to periodic, deterministic kicks, the QKR facilitates the study of transitions from diffusive to localized behaviour due to quantum interference effects. The quantum kicked rotor exhibits dynamical localization in momentum space, which is mathematically analogous to Anderson localization in disordered solids, where interference leads to the suppression of transport[2]. In our group, we implement cold atom kicked rotor systems that use laser-cooled atoms in optical lattices subjected to periodic kicks from pulsed laser fields to mimick the quantum kicked rotor[3]. In the first study[4], we investigated the effects of nonstationary Lévy noise in the kick sequence of an atom-optics kicked rotor. We observed that the introduction of Lévy noise leads to slower-than-exponential decay of coherences, manifesting as quantum subdiffusion. This behavior is highly sensitive to the Lévy exponent, offering a tunable mechanism for controlling transport properties in quantum systems. Following up on this, In Ref[5], we explored the dynamics of an atom-optics kicked rotor system by modifying the kick sequence. By flipping the sign of the kick sequence after every few kicks, achieved through half-Talbot time free evolution between kicks, we observed enhanced diffusion followed by asymptotic localization. This approach revealed localized yet nonexponential wave function profiles, suggesting a complex interplay between diffusion and localization mechanisms. Further, In Ref[6], we used the kicked rotor setup to study asymmetric dynamical localization. The introduction of half-Talbot time free evolution between kicks resulted in an asymmetrically localized momentum distribution, dependent on the initial velocity of the BEC. This asymmetry enabled precise measurement of the micromotion of the BEC, detecting small initial velocities with high sensitivity[6].

Keywords: Quantum kicked rotor, dynamical localization, quantum diffusion, Bose-Einstein condensate, micromotion measurement, Lévy noise.

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