Extended two-particle boson states in quasiperiodic chains

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The interplay of localization and many-body interactions has been a highly active research topic since the discovery of Anderson localization. While the direct theoretical study of such systems is quite complex and recently hotly debated, another route is taken by studying few interacting particles. The potential applicability to recent experimental activities with ultracold atoms in optical lattices, along with advancing techniques of single-atom manipulating, has brought the problem into a focus of attention.

It has been commonly accepted that interaction between two or three bosons in 1D lattices with localized single-particle states will only inflate their localization volume, if not localize it even better in certain cases. Here we report the first evidence of extended two particle states emerging due to interaction in a chain with quasiperiodic potential. While the depth of the lattice potential corresponds to the single-particle insulating regime, the two-particle states can become delocalized once the interaction strength reaches nonperturbative values. This transition can be understood as a result of the resonant mixing of the noninteracting two-particle eigenstates. Delocalization of two-particle states in the localized spectrum partly restores propagation of wave packets and marks the new dynamical regime that we coin 'correlated metal', in which two particles move coherently together through the whole chain. It also opens further questions such as on the structure of the two-particle spectrum and the fate of localization at higher particle numbers, even up to finite densities. We expect that these ideas inspire related experiments in non-equilibrium few-body dynamics, including and going beyond verifying the predictions.