Anderson localization of a non-interacting Bose-Einstein condensate

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One of the most intriguing phenomena in physics is the localization of waves in disordered media. This phenomenon had originally been predicted by P. W. Anderson, fifty years ago, in the context of transport of electrons in crystals¹, but it was never directly observed for matter waves. Ultracold atoms open a new scenario for the study of disorder-induced localization, due to the high degree of control of most of the system parameters, including interaction. For the first time we have employed a noninteracting ³⁹K Bose-Einstein condensate (BEC) to study Anderson localization². The experiment is performed with a 1D quasi-periodic lattice, a system which features a crossover between extended and exponentially localized states³ as in the case of purely random disorder in higher dimensions. We clearly demonstrate localization by investigating transport properties, spatial and momentum distributions. Since the interaction in the BEC can be controlled, this system represents a novel tool to solve fundamental questions on the interplay of disorder and interaction and to explore exotic quantum phases.

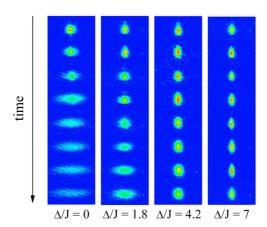


Figure 1: Images of the BEC expanding in the bichromatic lattice for different ratios between disorder amplitude Δ and tunnelling energy J. The crossover between ballistic expansion and localization is clearly shown.

¹P. W. Anderson, *Phys. Rev.* **109**, 1492 (1958).

²G. Roati et al., Nature (in press), preprint arXiv:0804.2609 (2008).

³S. Aubry and G. André, Ann. Israel Phys. Soc. **3**, 133 (1980).