Diffusion of ultra-cold atoms in an disordered pancake potential

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Abstract

When confined in two dimensions, numerous intriguing disorder related phenomena affect the transport properties of electrons in solid state systems. Recently, disorder-related phenomena started to be experimentally explored in atomic ultra-cold gases. Here, we present experimental results on diffusive expansion of an initially trapped 87Rb ultra-cold gas, confined along the vertical direction, in presence of an anisotropic disordered potential. Our experiment is a first step towards the study of other disorder effects in two dimensions, from anomalous subdiffusion [1] and classical trapping under the percolation threshold [2] to Anderson localisation [3].

The confinement in the horizontal plane is realized between the two lobes of a TEM01 blue-detuned beam [4,5], vertically focused and transversally collimated. The disordered potential is created by a speckle field [6], generated by a diffusive plate. We observe planar anisotropic diffusion of the low energy atoms and simultaneously ballistic expansion of the high energy atoms. After long expansion times, we extract quantitative informations on the energy dependence of the diffusion constants from the comparison of the observed density profiles with a diffusive model.

Keywords: Ultra-cold atoms, Disorder, Diffusion

References

[1] R. Metzler and J. Klafter, Physics Reports **339**, 1 (2000)

[2] L. N. Smith and C. J. Lobb, Phys. Rev. B **20**, 3653 (1979).

[3] P. Anderson, Phys. Rev. **109**, 1492(1958).

[4] T. P. Meyrath, F. Schreck, J. L. Hanssen, C. -S. Chuu, and M. G. Raizen, Optics Express **13**, 2843 (2005).

[5] N. L. Smith, W. H. Heathcote, G. Hechenblaikner, E. Nugent and C. J. Foot, J. Phys. B **38**, 223 (2005)

[6] D. Clément, A. F. Varon, J. A. Retter, L. Sanchez-Palencia, A. Aspect and P. Bouyer, New Journal of Physics **8**, 165 (2006)