Anderson localization of matter waves

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In 1958, P.W. Anderson predicted the exponential localization[1] of electronic wave functions in disordered crystals and the resulting absence of diffusion. It has been realized later that Anderson localization (AL) is ubiquitous in wave physics[2] as it originates from the interference between multiple scattering paths, and this has prompted an intense activity. Experimentally, localization has been reported in light waves [3] microwaves[4], sound waves[5], and electron gases[6] but to our knowledge there is no direct observation of exponential spatial localization of matter-waves (electrons or others). We present here the observation of Anderson localization[7] of a Bose-Einstein condensate (BEC) released into a one-dimensional waveguide in the presence of a controlled disorder created by laser speckle. We also show that, in our one-dimensional speckle potentials whose noise spectrum has a high spatial frequency cut-off, exponential localization occurs only when the de Broglie wavelengths of the atoms in the expanding BEC are larger than an effective mobility edge corresponding to that cut-off. In the opposite case, we find that the density profiles decay algebraically[8].

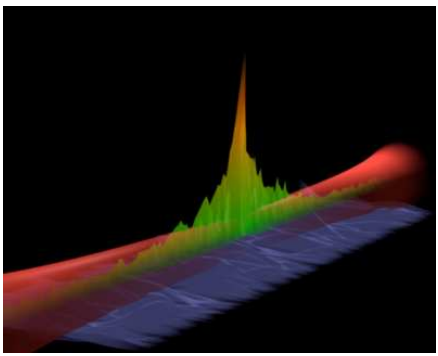

Figure 1: *Observation of Anderson localisation in 1D with an expanding Bose-Einstein Condensate in the presence of a 1D speckle disorder.*

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