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Damped Bloch Oscillations of Bose-Einstein Condensates in Disordered Potential Gradients

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We investigate both experimentally and theoretically disorder induced damping of Bloch oscillations of Bose-Einstein condensates in 1D optical lattices. Particles in periodic potentials subjected to an external force will undergo an oscillatory motion instead of a linear acceleration. A comparison with solid state systems, where scattering at imperfections of the crystal structure leads to a strong damping of these Bloch oscillations, gives rise to the question how the controlled addition of disorder to an optical lattice will affect the dynamics of particles in such systems. In our experiments the disorder is realised by a combination of a spatially inhomogeneous optical potential and a magnetic gradient. We show that this inhomogeneous force causes a broadening of the quasimomentum spectrum, which in turn results in a damping of the centre-of-mass oscillation. Good quantitative agreement of the experimental damping rates and the simulations using the Gross-Pitaevskii equation is obtained. Our results are relevant for high precision experiments on very small forces, which require the observation of a large number of oscillation cycles. Therefore a detailed quantitative understanding of the effect of the disorder and the underlying mechanism of the damping is important for such applications.