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Coherence freeze in an optical lattice investigated via two-dimensional pump-probe spectroscopy SAMANSA MANESHI, CHAO ZHUANG, CHRISTOPHER PAUL, LUCIANO CRUZ, AEPHRAIM STEINBERG, Centre for Quantum Information & Quantum Control and Institute for Optical Sciences, Department of Physics, University of Toronto, Canada — Motivated by our observation of fast echo decay and a surprising coherence freeze, we have developed a two-dimensional pump-probe spectroscopy technique for vibrational states of ultracold ^{85}Rb atoms in a 1D optical lattice to gain information on the memory dynamics of the system. In the 1D lattice, transverse motion of atoms through an inhomogeneous distribution of lattice depths gives rise to many frequency trajectories. We use pump-probe spectroscopy to characterize the probability distribution of these trajectories, and show that the inferred distribution, unlike a naive microscopic model of the lattice, correctly predicts the main features of the observed echo decay. Such techniques should be broadly useful for understanding (and subsequently correcting) decoherence in quantum information systems.

Chao Zhuang
Centre for Quantum Information & Quantum Control and Institute for Optical Sciences, Dept of Physics, University of Toronto, Canada

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