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Observation of Nonlinear Looped Band Structure of Bose-Einstein condensates in an optical lattice ELIZABETH GOLDSCHMIDT, US Army Research Laboratory, SILVIO KOLLER, Physikalisch-Technische Bundesanstalt, ROGER BROWN, ROBERT WYLLIE[1], National Institute of Standards and Technology, RYAN WILSON, US Naval Academy, TREY PORTO, National Institute of Standards and Technology — We study experimentally the stability of excited, interacting states of bosons in a double-well optical lattice in regimes where the nonlinear interactions are expected to induce "swallow-tail" looped band structure. By carefully preparing different initial coherent states and observing their subsequent decay, we observe distinct decay rates, which provide direct evidence for multi-valued band structure. The double well lattice both stabilizes the looped band structure and allows for dynamic preparation of different initial states, including states within the loop structure. We confirm our state preparation procedure with dynamic Gross-Pitaevskii calculations. The excited loop states are found to be more stable than dynamically unstable ground states, but decay faster than expected based on a mean-field stability calculation, indicating the importance of correlations beyond a mean-field description.

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