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Quantum Many-Body Tunneling of Solitons in Bose-Einstein Condensates JOSEPH GLICK, LINCOLN CARR, Colorado School of Mines — The macroscopic quantum tunneling of ultracold bosons is studied in one-dimensional optical lattice systems. A bright soliton confined by a potential barrier is allowed to tunnel out of confinement by reducing the barrier width or by tuning the strength of the attractive two-particle interactions. We predict the escape time for the soliton, that is, when the norm remaining behind the barrier drops to 1/e. Time-Evolving Block Decimation (TEBD), a time-adaptive matrix product state method, is used to accurately model the many-body physics. Using mean-field calculations as a comparison, we independently check our results near the weakly interacting limit. We examine how the interaction strength, the number of particles, the system size, and the barrier area affect the soliton escape time. Our findings show the regimes in which the mean-field theory is widely inadequate, and the appreciable differences between a mean-field and a full quantum many-body approach. We then use TEBD to model the dynamics far beyond the mean-field limit. We calculate the entropy of entanglement between the soliton body behind the barrier and the escaped soliton tail past the barrier over time. Using two-particle correlation functions we also examine how particles in different regions of the many-body system (behind, under, or past the barrier) are entangled to one another.

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