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Macroscopic Quantum Tunneling of Solitons in Bose-Einstein Condensates[1] JOSEPH A. GLICK, LINCOLN D. CARR, Colorado School of Mines — We study the macroscopic quantum tunneling of ultracold bosons in one-dimensional optical lattices. A bright matter-wave soliton behind a potential barrier is allowed to tunnel out of confinement by tuning the barrier width and the attractive particle-particle interactions. We predict the escape time for the soliton, that is, when the norm remaining behind the barrier drops to 1/e, modeling how the interaction strength, the system size, and the barrier dimensions affect the escape time. We preform quasi-exact simulations of the quantum many-body entangled dynamics with Time-Evolving Block Decimation (TEBD), a matrix product state numerical method. Independently, we check our results near the weakly interacting limit with mean-field theory. Our findings show the regimes in which 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. We use density-density correlation functions to examine how particles in different regions of the system (behind, under, or past the barrier) are entangled to one another.

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