Correlation Effects in the Ground State and Nonequilibrium Dynamics of One-Dimensional Quantum Droplets

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We exemplify the impact of beyond Lee-Huang-Yang (LHY) corrections, especially due to intercomponent entanglement, in the ground state and the quench dynamics of one-dimensional so-called quantum droplets using a nonperturbative approach. It is found that the droplet gaussian-like configuration arising for intercomponent attractive couplings becomes narrower for stronger intracomponent repulsion. A transition towards a flat-top structure either for larger particle numbers or intercomponent attractions is evinced. Additionally, a harmonic trap prevents the flat-top formation. In the absence of mean-field interactions, we show that quantum fluctuations prevent the collapse of LHY fluids for larger atom numbers and a correlation hole is present in the few particle limit of these fluids as well as for flat-top droplets. Introducing mass-imbalance, droplets experience intercomponent mixing, and excitation signatures are identified for larger masses. Monitoring the droplet expansion (breathing motion) upon considering interaction quenches to stronger (weaker) attractions, we explicate that beyond LHY correlations result in a reduced velocity (breathing frequency). Strikingly, the droplets feature two-body anti-correlations (correlations) at the same position (longer distances). Our findings pave the way for probing correlation-induced phenomena of droplet dynamics in current ultracold atom experiments.