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Correlated Quantum Dynamics of a Single Atom Collisionally Coupled to an Ultracold Finite Bosonic Ensemble SVEN KRÖNKE, JOHANNES KNÖRZER, Center for Optical Quantum Technologies, University of Hamburg, Hamburg, Germany, PETER SCHMELCHER, Center for Optical Quantum Technologies, University of Hamburg, Hamburg, Germany; The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany — We explore the correlated quantum dynamics of a single atom with a spatio-temporally localized coupling to a finite bosonic ensemble [*arXiv:1410.8676*]. The single atom is initially prepared in a coherent state of low energy and oscillates in a harmonic trap. An ensemble of N_A interacting bosons is held in a displaced trap such that it is periodically penetrated by the single atom. The non-equilibrium quantum dynamics of the total system is simulated by means of an *ab-initio* method. Here, we focus on characterizing the impact of the peculiar inter-species coupling and the thereby induced inter-species correlations on the subsystem states: At instants of not too imbalanced excess energy distribution among the subsystems, inter-species correlations prove to be significant. A phase-space analysis for the single atom reveals that these correlations manifests themselves in short phases of strong deviations from a coherent state. In the bosonic ensemble, the single atom mainly induces singlet and delayed doublet excitations, for which we offer analytical insights with a stroboscopic time-dependent perturbation theory approach. When increasing the ensemble size, its maximal dynamical quantum depletion is shown to decrease faster than $1/N_A$ for a fixed excess energy.

Sven Krönke
Center for Optical Quantum Technologies,
University of Hamburg, Hamburg, Germany

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