Effect of Interatomic Separation in Ensembles in Determining the Fidelity of Collective Excitation

RESHAM SARKAR, MAY KIM, YAN-FEI TU, RENPENG FANG, SELIM SHAHRIAR, Northwestern University — An ensemble of $N$ independent non-interacting two-level atoms gets excited to $2N$ states on interaction with a classical laser. Of these, only $N + 1$ are symmetric. In the regime where the interatomic separation, $\Delta z$, is much smaller than the wavelength of radiation, $\lambda_L$, and the atoms do not overlap, the asymmetric states disappear and the cluster is reduced to a manifold of symmetric states. However, when $\Delta z \gg \lambda_L$, the asymmetric states remain coupled to the ensemble. In this talk, we will describe a technique to determine the dependence of the symmetric and asymmetric states on $\Delta z$. We will show the algorithm for determining the asymmetric states corresponding to any $n$ of $N$ atoms in the excited state. The number of atoms in the excited state and the size of the cluster govern the dependence of the ensemble on $\Delta z$. An understanding of the evolution of these states is imperative for the realization of a collective state atom interferometer, where the Compton frequency is $N$ times higher than that of a single atom. The scale factor, defined as phase shift for a given rate of rotation, for such an interferometer increases linearly as $\sqrt{N}$ for a given area.

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