Entanglement of an impurity in a few-body one-dimensional ideal Bose system

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We study the correlation between an impurity and a small ensemble of bosonic particles in one dimension. Our study analyzes the one-body density matrix and calculates the corresponding von Neumann entanglement entropy as a function of the interaction strength between the impurity and the bosons when all particles have the same mass. We show that the entropy grows very fast for small and moderate interaction strength and then increases slowly toward the strongly interacting regime. Then we study the effect over the quantum correlations of a mass imbalance between the impurity and the bosons. In the strongly interacting case, we discover that when the impurity is much heavier than the bosons, then we have the least possible correlation. However, the entropy tops its maximum when the mass ratio is between 3 and 4 in the case where there are four bosonic particles and then falls off to its minimum for higher mass imbalance.

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