Undamped oscillations in the long-time magnetization dynamics of a quantum spin chain

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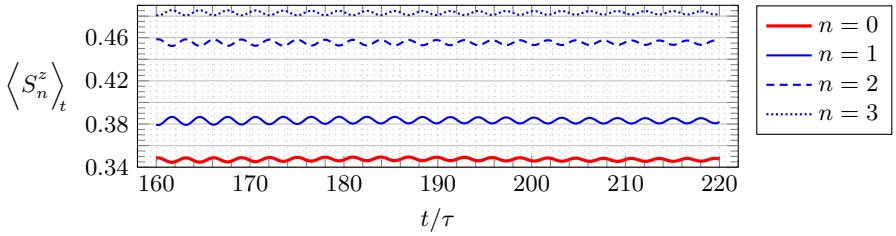
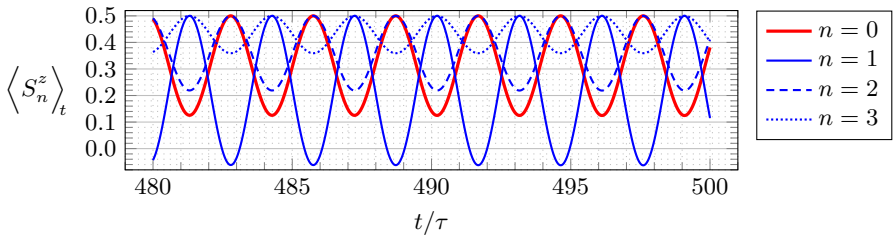
We study the magnetization dynamics of a semi-infinite XY quantum spin-1/2 chain with an impurity at site $n = 0$. The model has exact diagonalization. Besides a continuous band there are two localized states, called impurity states, which exist only for some regions in the system parameter space. Assuming a general initial state in which each 'atom' can be found in state up or down, exact analytical expressions are obtained for the site magnetization. The long-time behavior is derived using the stationary phase approximation. Six characteristic regions in the parameter space are identified implying each a different qualitative long-time behavior. By considering a specific initial state it is shown that the existence of impurity states leads to different asymptotic values of the magnetization at the chain sites (figures below, where $\tau = \hbar/|J|$, being J the host exchange-interaction constant). When two impurity states exist, the quantum interference between them yields magnetization oscillations which settle over time with a constant amplitude (second figure below). The study of the dynamics of quantum spin chains is of interest to the general theory of non-equilibrium processes in quantum many-body systems and is also relevant in the proposal to use spin chains as quantum information transfer channels. [1]





[1] S. Bose *et al.*, "Spin chains as data buses, logic buses and entanglers", in *Quantum state transfer and network engineering* (Springer, 2014), p. 1.