B. Case of the Gaussian wave packet

We next consider a Gaussian wave packet with a width $\sigma = 0.1\lambda$, such that the wave packet exactly fits into the left well located at $x = 0$. At the boundaries of the double-well, the wave packet almost vanishes. This wave packet is a superposition of several eigenfunctions of the lattice, as mentioned before.

We show in Fig. 6 the temporal variation of the probability that the wave packet remains in the initial left well. Clearly, for larger kick strength and larger kick rate, the wave packet gets diffused throughout the lattice. The much larger kick rate leads to faster diffusion without any oscillation. However, for weak kick strength [see Figs. 6(a), 6(c)], the wave packet starts oscillating back and forth between the initial left well and the right well. This result is complemented by the plot of the survival probability in Fig. 7, which shows that the state is preserved for the corresponding parameters.

A comparison of the Figs. 5(a) and 7(a) reveals that for an initial Gaussian wave packet, a moderate kick strength preserves the survival probability for longer times, whereas for an initial state $|L\rangle$, this vanishes rapidly. This observation leads us to the main result of our paper: A suitable superposition of several wave functions provides longer preservation of the state of the system than a superposition of a fewer wave functions. Note that the Gaussian wave packet is made up of several eigenfunctions of the system, where the state $|L\rangle$ is a superposition of only two eigenfunctions.

As the survival probability does not refer coherence, we further choose to study the temporal behavior of the purity $M(t)$. $M(t) = 1$ refers to a pure state. In Figs. 8 and 9, we have shown that the purity in the Gaussian wave packet decays in a slower rate than that in the state $|L\rangle$ for different sets of values of kick rate and kick strength. For a moderate kick rate (100 Hz) and a moderate kick strength ($m = 10$), the Gaussian wave packet exhibits a purity ~ 0.8, which is much larger than that (~ 0.3) of the state $|L\rangle$ at a time $t \sim 40/E_R$ [see Fig. 8(a)]. This further verifies the fact that a suitable superposition of the energy eigenfunctions exhibits a better preservation of coherence in the external states of the atoms.