Superadiabatic Approximations for Cooper Pair Pumping

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Cooper pair pumping is a process of transferring charge via external manipulation of the system parameters providing a way to study the geometrically and dynamically accumulated quantum phases. Depicting the dynamics of such steered systems coupled to a dissipative environment has remained an unsolved problem until recently.
Based on a recently derived master equation,[1,2,3] we introduce a numerical method where successive coordinate transformations are applied to decrease the error resulting from truncation in the local adiabatic parameter. We then show that our method applied to a well-known pumping problem reduces the non-physical behaviour observed previously and that the environment-induced relaxation leads to adiabatic ground-state pumping only in the lowest-order approximation. We illustrate the robustness of the frequency where the adiabaticity breaks down using the higher-order theory and show the emergence of an optimal environmental coupling strength where ideal pumping is preserved for the highest frequency. Finally, we give an estimate for the relaxation rate of an experimentally measured system.

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