A classical route to quantum control

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Quantum "shortcuts to adiabaticity" are strategies for quickly achieving a result that would ordinarily require a long, slow process. The basic goal is to guide a system to evolve from an eigenstate of an initial Hamiltonian H_0 to the same eigenstate of a final Hamiltonian H_1, without having to vary the Hamiltonian slowly (adiabatically) with time. Although formal solutions to this problem exist, they are often difficult to translate into laboratory settings. I will argue that classical mechanics can help to achieve this goal.

The classical version of the quantum problem can be formulated precisely and solved exactly for a generic one-dimensional Hamiltonian that varies rapidly with time. Specifically, for a Hamiltonian H(q,p,t), and for an arbitrary choice of action I_0, I will show how to construct a "fast-forward" potential energy function V_{FF}(q,t) that deftly guides all trajectories with initial action I_0 to end with the same value of action. The solution is surprising simple, relying only on elementary manipulations of Hamilton's equations [1]. When this classical solution is applied to the quantum Hamiltonian, the result is a quantum shortcut to adiabaticity, which guides a wavefunction to the desired final energy eigenstate with high accuracy.

[1] C. Jarzynski, S. Deffner, A. Patra and Y. Subasi, "Fast forward to the classical adiabatic invariant", Phys Rev E **95**, 032122 (2017)