Title:	Quantum Otto engine with exchange coupling in the presence of level degeneracy
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Abstract:	We consider a quasistatic quantum Otto cycle using two effectively two-level systems with degeneracy in the excited state. The systems are coupled through isotropic exchange interaction of strength J>0, in the presence of an external magnetic field B which is varied during the cycle. We prove the positive work condition and show that level degeneracy can act as a thermodynamic resource, so that a larger amount of work can be extracted than in the nondegenerate case, both with and without coupling. We also derive an upper bound for the efficiency of the cycle. This bound is the same as derived for a system of coupled spin-1/2 particles [G. Thomas and R. S. Johal, Phys. Rev. E 83, 031135 (2011)], i.e., without degeneracy, and depends only on the control parameters of the Hamiltonian, being independent of the level degeneracy and the reservoir temperatures.
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