Coherent ergotropy in thermalized intra-system couplings

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In this study, we delve into the interplay between ergotropy, the extractable energy by unitary operations and thermodynamic work input. Focusing initially on a single two-level system (TLS), we establish a direct correspondence between work input, required for changing the TLS transition frequency, and its ergotropy, assuming the state of system is pure. However, presence of mixedness breaks the correspondence between the extractable energy and the injected one (work), the latter being consistently larger than the former. Expanding our investigation to a two-TLS thermal state governed by a model with proper interaction which allows for local coherence (and coherent ergotropy, in turn) generation, as explored by some of us [1], we uncover a non-trivial relation between the work input needed to manipulate the frequency of one of the subsystems and its ergotropy. This reveals a mechanism whereby the work done on the system is partially converted into extractable energy, particularly in a scenario where the ergotropy originates only from coherence and not population inversion. We compare these results to a similar two-TLS thermal state under a model with xx interaction (transverse Ising model) which lacks the local coherence generation feature. Here, we identify a loss-loss scenario, wherein the injected work remains inaccessible as it can not be transformed to a useful form of energy, i.e. ergotropy. Our research illuminates the relation between important energy-transformation concepts in quantum systems. By elucidating these relationships, we contribute to a deeper understanding of the energy-transformation properties of quantum systems, offering insights into energy storage or transfer processes and their implications for quantum technologies

[1] M. Kolář, & R. Filip, arXiv preprint arXiv:2211.08851 (2022).