

# Is coherence catalytic?

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Quantum coherence, the ability to control the phases in superposition states is a resource, and it is of crucial importance, therefore, to understand how it is consumed in use. It has been suggested that catalytic coherence is possible, that is repeated use of the coherence without degradation or reduction in performance. The claim has particular relevance for quantum thermodynamics because, were it true, it would allow free energy that is locked in coherence to be extracted *indefinitely*. We address this issue directly with a careful analysis of the proposal by Åberg [1]. We find that coherence *cannot* be used catalytically, or even repeatedly without limit.

Here we present an analysis of a proposal by Åberg that coherence is catalytic [1] or, perhaps more accurately, that it is a resource that can be used repeatedly without degradation in performance [2]. We ask, specifically, whether the coherence in Åberg's proposal is indeed catalytic or repeatable and show that it is *neither*.

Quantum coherence is a strictly finite resource. Repeated use inevitably degrades and ultimately consumes it. Once eliminated the residual coherence source performs no better than one prepared randomly. In the Åberg proposal this is reflected in the *complete destruction* of reservoir coherence following a *single* and ultimately inevitable error in the transfer of the phase reference to a qubit.

[1] Åberg J 2014 Catalytic coherence *Phys. Rev. Lett.* **113** 150402.

[2] Korzekwa K, Lostaglio M, Oppenheim J and Jennings D 2016 *The extraction of work from quantum coherence* *New J. Phys.* **18**, 023045.