Università degli Studi di Padova

QUEST - Quantum energy storage and transfer

Energy management has always been crucial, throughout history, in advancing technology, enhancing productivity and fostering sustainable development. It is thus not surprising that even now, at the verge of the second quantum revolution, the field of quantum thermodynamics is emerging as one of the most vibrant branches of quantum many-body physics. A key focus of this research area is the conversion of heat, work, and information within quantum systems and, as a consequence, the conceptualization of quantum thermal machines, such as quantum thermal engines, refrigerators, and quantum batteries, which leverage quantum effects like superposition, entanglement, and coherence to extract and transfer energy between quantum systems. Among these, quantum batteries stand out for their potential to achieve faster and more efficient charging processes compared to their classical counterparts, as demonstrated by pioneering studies on the realization of the quantum Dicke battery, which showed a collective speedup of the charging process. These outstanding results have motivated a growing interest towards these quantum technologies. However, despite significant progresses, the field still faces numerous challenges, including stabilization of stored energy, optimization of charging protocols, and enhancement of energy transfer. Within this context, the limitations of current simulation techniques, which often rely on exact diagonalization, restrict the exploration of larger and more complex systems, particularly in higher dimensions. Therefore, as energy management continues to be pivotal in technological advancements and sustainable development, QUEST seeks to address the need for breakthroughs in the development of quantum energy devices, advancing the current state-of-the-art in the field of quantum technologies for energy storage and transfer by developing efficient numerical simulations tools for the design and characterization of many-body quantum batteries.

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