# Reliable quantum advantage in quantum battery charging

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Quantum batteries [1] are quantum systems, such as superconducting qubits or trapped ions, that can store energy after being charged, and eventually deliver it on demand. Despite the increasingly growing interest around these devices [2], nowadays their importance lies in the fact that they lend themselves to being described by a thermodynamic point of view, hence favoring the study of energy exchanges and, most of all, energy fluctuations [3] in the framework of quantum statistical theory. In fact, the more the dimensions of the devices are reduced to the nanoscale, the smaller the energy quantities to be stored, and the more the amplitude of fluctuations is comparable to them. In any realistic usage of quantum technologies, e.g., for an efficient quantum computation, it is necessary to limit fluctuations in order to reduce the presence of noise. Besides, a better knowledge of fluctuations allows also to individuate the less-fluctuating processes, thus indicating a preferable route towards the development of more precise quantum devices and the optimization of quantum technologies.

In our work [4] we study a Jaynes-Cummings quantum battery (JCQB), i.e., a device consisting of a flying qubit interacting with an optical resonator (see schematic illustration in Figure 1a). By employing the Full Counting Statistics [3], we analytically find that it is possible to enhance the charging performance of the battery by preparing the single-mode resonator in a genuine *quantum* and *non-Gaussian* state. In fact, if the cavity mode is initialized in a Fock state $|N\rangle\langle N|$, the charging process is more efficient than other protocols, e.g., processes involving a cavity in a "classical" coherent state or in a Gaussian (yet quantum) squeezed state. We prove such advantage in the Fock state cavity protocol by evaluating the signal-to-noise ratio (SNR) shown in Figure 1b, which quantifies how good is the signal (the average energy injected into the battery) with respect to its fluctuation (the variance). We find that the advantage is *reliable*, since it takes into account the dynamical energy fluctuations occurring during the process. This result suggests that understanding the dynamics of fluctuations in quantum batteries is of paramount importance, since the same advantage that can emerge from these models could be exploited to refine the efficiency of quantum technologies, by analysing the energy fluctuations that take place in their core processes.

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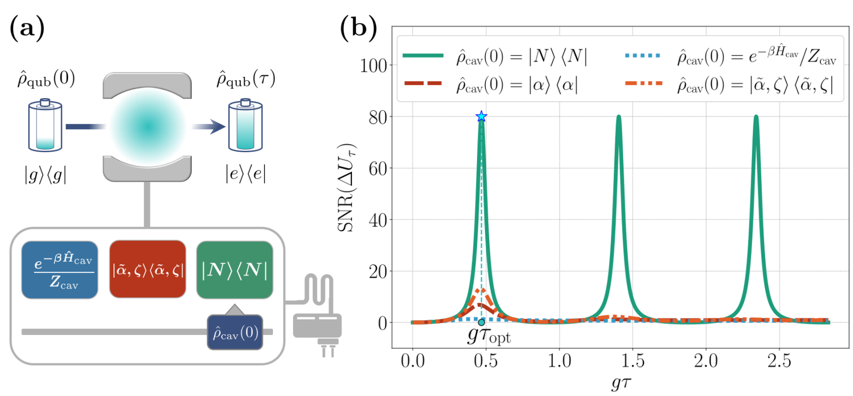


FIG. 1. (a) Scheme of the JCQB proposed in this work [4]. (b) Signal-to-noise ratio (SNR) associated with the injected energy.