NATURAL FREQUENCY CUTOFF IN THE RESONATOR-WAVEGUIDE COUPLING STRENGTH OF A QUANTUM LINK

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Due to hardware limitations near-term quantum processors are currently constrained in size. However, a potential solution to this issue is the establishment of quantum links between quantum processors. While not as ambitious or complex as a full-fledged quantum internet, these coherent channels facilitate larger scale distributed quantum computations (DQC) and the interconnection of quantum processors with auxiliary components like sensors and memories. In the quantum links presented in [1,2], two kinds of coupling strengths ought to be considered, the one between the qubit and the resonator and the one between the resonator and the waveguide. While the former is well fathomed, the latter and namely its high frequency behavior remains a bit of a conundrum. It is standard in quantum optics to incorporate an *ad hoc* frequency cutoff in the corresponding spectral function, either smooth or sharp. Nonetheless, this cutoff is critical for the conducted numerical simulations hence requiring a more thorough investigation. Fortunately, a recent article [3] undertook a rigorous formulation of the coupling strength of a transmission line coupled to a network of degrees of freedom which ultimately leads to a natural cutoff frequency. Our scope of work aims at adapting this derivation to the physical problem at hand which could pave the way for a heightened understanding of the engineering and control of quantum links.

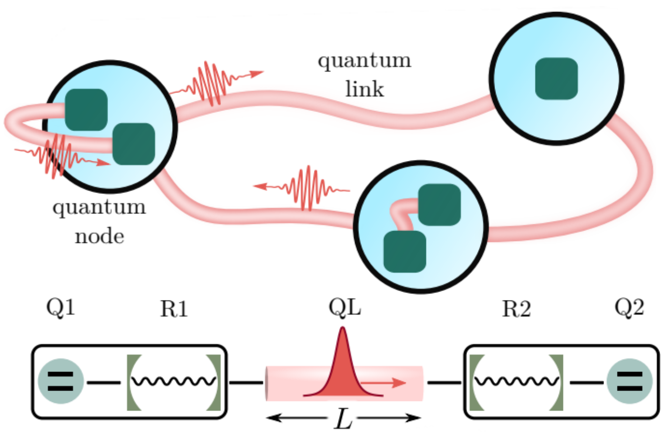

Figure: Schematic representation of a quantum link (above) and abstract quantum optical modelization of the studied quantum link (below).[1]

References:

[1] Peñas, G. F., Puebla, R., Ramos, T., Rabl, P., & García-Ripoll, J. J. (2022). Universal deterministic quantum operations in microwave quantum links. Physical Review Applied, 17(5), 054038.

[2] Peñas, G. F., Puebla, R., & García-Ripoll, J. J. (2022). Improving single-photon quantum operations: Correcting non-Markovian and distortion effects. arXiv preprint arXiv:2212.04899.

[3] Parra-Rodriguez, A., Rico, E., Solano, E., & Egusquiza, I. L. (2018). Quantum networks in divergence-free circuit QED. Quantum Science and Technology, 3(2), 024012.