Contribution ID: **11** Type: **not specified**

High efficiency microwave-optical transduction for quantum sensing and computing

Monday, July 18, 2022 8:40 PM (20 minutes)

Superconducting radio-frequency (SRF) cavities play a crucial role in quantum computing and various quantum applications. These cavities also provide powerful tools to probe fundamental physics. At Fermilab, we are exploring ways to use hybridized SRF cavities as quantum transducers to convert microwave-optical quantum signals with high fidelity and high efficiency. Currently, quantum transduction demonstrations are limited in conversion efficiency, with most schemes operating in the high-pump regime, therefore with large noise. Our strategy exploits Fermilab's 3D bulk niobium cavities using high densities of electromagnetic fields in large RF volumes. We couple these cavities to noncentrosymmetric crystals, used as optical resonators. The large flexibility of the cavity geometry provides new degrees of freedom to optimize the microwave-optical coupling strength. The high microwave quality factor and large coupling strength between microwave and optical modes are expected to lead to orders of magnitude enhancements for transduction efficiency at a low pump power of tens of μW. We present ongoing and future research on optical-microwave transduction, which would have an impact on single-photon sensing and networks, with the ability to perform measurements below the standard quantum limit (SQL). In quantum sensing up/down photon conversion may also enable highly sensitive axion and dark photon haloscope searches in the THz regime. In quantum computing these hybrid devices would be a first building block for the realization of distributed quantum networks.

In-person or Virtual?

In-person

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Session Classification: Poster Session