High-Q cavity coupled to a high permittivity dielectric resonator for sensing applications

Shahnam Gorgi Zadeh,[1]Alberto Ghirri,[2] Sergio Pagano,[3] Simone Tocci,[4] Claudio Gatti,[4] and Antonio Cassinese[5]

1. European Organization for Nuclear Research (CERN), Meyrin 1217, Switzerland

2. Istituto Nanoscienze - CNR, Centro S3, via G. Campi 213/A, 41125, Modena, Italy

3.Physics Department, University of Salerno and INFN GC Salerno, via Giovanni Paolo II 132, Fisciano (SA), Italy

4.INFN, National Institute for Nuclear Physics, I-00044, Frascati, Italy

5 Physics Department and INFN -Napoli, Universit`a Napoli Federico II, P.le Tecchio 80, 80125 Naples, Italy

Abstract: We report on coupled cavity configuration whith high Q-factor elliptical TESLA-shaped superconducting cavity is coupled with a high permittivity (εr) SrTiO3 puck measured down T=0.2K. Extensive electromagnetic simulations are used to test different coupling configurations.

The use of high-quality factor resonators is of undoubted interest for high precision measurements and for applications in quantum technologies. Novel types of microwave sensors can be realized by coupling a first resonator acting as a stable frequency reference with a second resonator that is sensitive to a particular physical quantity. Here we report on a coupled cavity configuration in which a high Q-factor elliptical TESLA-shaped superconducting cavity is coupled with a high permittivity (εr) SrTiO3 puck, whose resonant frequency varies as a function of temperature due to the temperature dependence of the permittivity that reaches values higher than 30000 below 1 K.

Extensive electromagnetic simulations are used to test different coupling configurations, showing great versatility to tune the coupling in the weak or strong regime, depending on the puck's position within the cavity. Moreover, for the coupled system, they allow one to investigate the dependence of the zero-transmission frequency value on changes of the permittivity εr, obtaining a maximum value of 2.8 MHz per unit change of εr, for $\varepsilon r \approx 230$. Finally, we discuss a specific application of the coupled system as a bolometer in different temperature ranges. Details are reported in [1].

References

[1] S. G. Zadeh, A. Ghirri, S. Pagano, S. Tocci, C.Gatti, A.Cassinese, https://arxiv.org/abs/2410.05831