Contribution ID: **103** Type: **not specified**

Exploring the perspectives of superconducting materials in SRF for quantum sensing

Thursday 19 September 2024 15:48 (23 minutes)

RF properties of superconductors (SC) in high magnetic fields have recently become of great interest in view of their applications in large experiments in fundamental physics. Indeed, the quantum sensing of dark matter axions [1] and other elusive signals such as high frequency gravitational waves (GW) [2], or the beam screen for the CERN Future Circular Collider (FCC) [3], can greatly benefit from SC low RF dissipation in the vortex state.
The realization of high-Q SC rf cavities for quantum sensing of axions (haloscopes), and possibly of GW, requires both the understanding and subsequent optimization of the surface impedance Z of the material, with a focus on the dynamics of pinned vortices which govern the achievable Q, and the related development and tuning of the coating technique.
Beside the leading actors (vapor diffused Nb3Sn, sputtered NbTi [1], YBCO tapes glued on multipiece cavities), other innovative SC, namely Fe-based and Tl1223, could play a role due to the potentially more scalable deposition techniques (electrodeposition and high pressure reaction, respectively), despite the present embryonic development phase.
Starting from measurements of Z in the 14-27 GHz range, in dc magnetic fields, in well-developed SC (NbTi, YBCO), we identify the main physical properties responsible for the performances of haloscopes. Although obviously vortex pinning plays a major role, the often-disregarded flexibility of vortex lines and the length of the penetration depth strongly affect the overall Q in real haloscopes, so that the choice of the material is not obvious.
Based on these findings, we present an improved comparison of the potential performances of several SC materials, including more exotic Fe-based, evaluated in a large (temperature, field, frequency) parameter space [4].

Acknowledgments
This work has been partially supported by INFN CSN5 project SAMARA, MUR-PRIN Project IronMOON Grant No.2022BPJL2L, FCC collaboration under MoU Addendum FCC-GOV-CC-0218(KE5084/ATS). We acknowledge sample preparation and useful discussion with S. Calatroni, C. Gatti, G. Ghigo, C. Pira, S. Posen, M. Putti, R. Vaglio.

References

1. D. Alesini et al, PRD 99, 101101(R) (2019)
2. A. Berlin et al, PRD 105, 116011 (2022)
3. S. Calatroni, IEEE TAS 26, 3500204 (2016)
4. A. Alimenti et al, Instruments 6, 1 (2022)"

Authors: SILVA, Enrico; POMPEO, Nicola (Roma Tre University)

Presenter: SILVA, Enrico

Session Classification: Perspective of SRF thin films in accelerators and other applications

Track Classification: Perspective of SRF thin films