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Perspectives of superconducting materials in SRF at high fields for large physics experiments

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Large experiments in fundamental physics such as the detection of dark matter axions [1] or new particle accelerators like the CERN FCC [2], can greatly benefit from the low surface impedance Zs of superconductors (SC) in high magnetic fields H. In the pursuit of high-Q SC cavities (haloscopes), the understanding and control of high frequency vortex motion, the main dissipative channel acting in the mixed state, is of paramount importance. We propose a microwave (ν=8-27 GHz) study at high H, ≤12 T, of Zs in Nb3Sn samples grown by different techniques: high isostatic pressure sintering (HIP), vapor diffusion (VD), and DC magnetron sputtering (DCMS). Using a dual frequency dielectric loaded resonator, vortex dynamics parameters are extracted. Several results are deduced for the various Nb3Sn samples: the HIP sample presents effective, albeit collective, pinning; the VD sample exhibits a weak collective pinning overcome already at a few T; the DCMS sample shows a marked signature of Josephson coupled network of grain boundaries, sites for the effective pinning observed. Secondly, we present a broad comparison of the potential performances of several SC, evaluated in a large (T, H, ν) parameter space [3]. It is inferred that, althoughvortex pinning plays obviously a major role, the often-disregarded flexibility of vortex lines and the penetration depth strongly affect haloscopes Q, so that the choice of the material is not obvious.

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Yes

Footnotes

[1] D Alesini et al, Phys. Rev. D 99, 101101(R) (2019)
[2] S Calatroni, IEEE Trans. Appl. Supercond. 26, 3500204 (2016)
[3] A Alimenti et al, Instruments 6, 1 (2022)

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