Revealing the loss mechanisms of a 3D aluminium cavity

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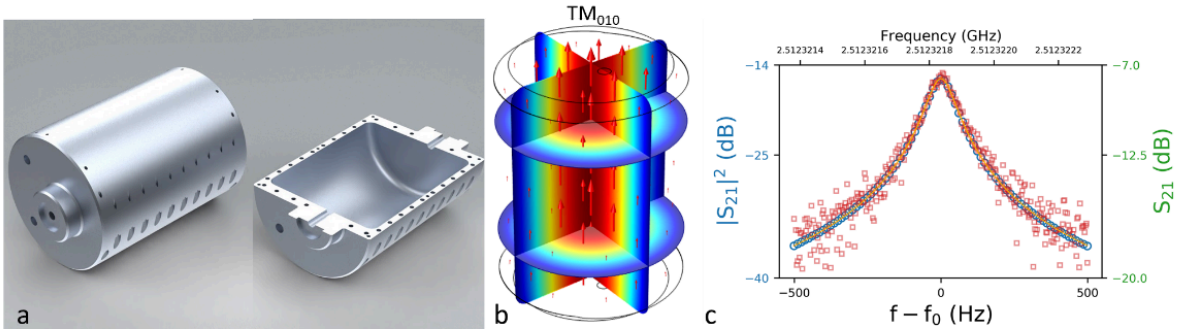

Superconducting microwave cavities have found applications in many areas including quantum computing, particle accelerators, and dark matter searches. Their extremely high quality factors translate to very narrow bandwidth, which makes them key components of sensitive detectors. In this study, we aim to understand the loss mechanisms of an aluminium cavity, with a fundamental mode TM010 frequency of about 2.5123 GHz, and how they change as the cavity material transitions from the superconducting to normal state. We found that at temperatures not much lower than the transition temperature losses are dominated by quasiparticle excitations and are well described by the BCS theory. The exponential decrease of the quasiparticle density as temperature is lowered results in a 1000-fold increase of the quality factor, as well as a shift of the resonance frequency due to the change of the kinetic inductance of the superconductor. At very low temperatures, losses due to two-level systems begin to dominate, giving a peak in the quality factor of about 2.76×10^7 at 130 mK. Understanding the loss mechanisms is invaluable, as the working temperature of the cavity may vary during operation regardless of its application.

Yuri Pashkin is Professor of Experimental Condensed Matter Physics at Lancaster University. Since joining Lancaster in 2012, he has led the launch of the Quantum Technology Centre and coordinated major UK and European research projects. He has held visiting positions at leading institutions across Europe and Japan. His research spans quantum technologies (computing, metrology, sensing) and nanoelectronic/nanoelectromechanical devices. He is a Fellow of the Institute of Physics, recipient of the Royal Society Wolfson Research Merit Award, and widely recognized for his contributions to superconducting quantum devices.