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Two different origins of Q-slope problem in a Nb film cavity for HIE-ISOLDE

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Since their invention, the performance of Nb film cavities has always been limited by a strong Q-slope. Recent tests at CERN of the newly developed seamless Quarter-Wave Resonator (QWR) showed an interesting decomposition of the Q-slope, which might help to explain/cure this limitation. One is caused by non-linear trapped flux oscillation in the residual component, whose surface resistance depends linearly on the RF field strength. The other is the medium-field Q-slope, which depends exponentially on temperature and RF field. Once the trapped flux is suppressed by using magnetic field compensation during cool down upon superconducting transition, the cavity's Q-slope at superfluid temperature was as small as for bulk Nb cavities up to peak magnetic fields of 120 mT. We argue that the Q-slope problem in low-frequency Nb film cavities originates from environmental conditions. These cavities are typically operated in normal fluid without magnetic shielding. Thermal gradients in the previous design of HIE-ISOLDE QWRs may give rise to thermoelectric currents during cool down, and thus dominate trapped-flux induced Q-slope in the residual resistance. We also study the fundamental cause of medium-field Q-slope and compare it with several models. Reducing the Q-slope of Nb coated cavities would make them an interesting and cost-effective alternative to bulk Nb cavities for an increased number of applications.

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