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Experimental analysis of quench behavior in a Cable-In-Conduit-Conductor cooled by stagnant superfluid helium

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The MADMAX project is a dark matter Axion research project where the mass of which is expected to be in the range of 100 μeV. To study this particle, a large superconducting dipole magnet composed of 18 coils and generating a field of 9 T in a 1.35 m bore has been designed. For this application, a new conductor have been developed in a Cable-In-Conduit-Conductor (CICC) configuration with a copper stabilizer and cooled with stagnant superfluid helium in the CICC channel. As several hundreds of meters separate the center of each coil from the helium bath surrounding the whole magnet, and given the small helium cross-section in the CICC, quench dynamics is clearly an issue for the MADMAX project.

In order to study experimentally the quench propagation in such a magnet, we designed a MADMAX-like solenoidal prototype called MACQU based on numerical modeling performed with THEA®. The goal of this study is to measure a MADMAX-like quench propagation velocity to demonstrate that the magnet protection design is safe. Another target of the study is to compare the experimental results with numerical computations that predict two different dynamic phases: a first quench propagation with a constant speed and a second one with acceleration. The MACQU coil prototype has been instrumented to capture the quench propagation phenomenon with heaters, temperature sensors, voltage taps and SQD (Superconducting Quench Detection wires).

This paper will give the main features of the MACQU coil design and the rationale behind it to be representative of the Madmax quench behavior. The whole experiment will be presented including instrumentation and quench test protocols. The experimental data will be analyzed in detail in order to identify the main physical phenomenon driving the quench dynamics. Finally, the experimental velocities will be compared to the numerical ones and the results discussed.

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