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Thu-Af-Or24-01: Diagnostics and control of superconducting magnets using diffuse field ultrasound

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Among various superconducting magnet diagnostics, acoustic techniques are valuable for characterizing mechanical instabilities associated with lengthy training, premature quenching and other performance limitations. While acoustic emissions from magnets were studied since early 80s, techniques involving external acoustic excitation have so far been of limited use. As such techniques are already well-developed in materials science and geosciences, they offer a great potential for the superconducting magnet applications. In a typical magnet coil an acoustic pulse emitted by a coupled ultrasonic transducer would experience multiple scatterings from boundaries and interfaces along its propagation path, in resemblance to a diffusion process. The resulting diffuse ultrasonic field uniquely "encodes" geometrical constrains, scatters locations and sound velocity distribution in the propagation medium. Variation of these properties can then be tracked in real time and with high accuracy by monitoring shape distortions and temporal shift of the ultrasonic waveforms acquired by sensors coupled to the coil. In this talk, key physical principles and capabilities of the diffuse field ultrasound will be discussed, and examples given of using it for detecting mechanical instability precursors and hot spot formation in various superconducting coils and sub-scale magnets developed by the US. Magnet Development program. Also, we will discuss application of the "time-reversal" acoustic method for the focused deposition of ultrasonic energy at a specific location inside the superconductor, aiming at a possibility of using it for magnet protection and mitigation of training.

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