Joint DESY and University of Hamburg Accelerator Physics Seminar

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(16:00 in Room 459/30b)

Advanced Superconducting Undulators: Promise and Technology Hurdles

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Abstract

There has been significant progress in the performance of commercially-available advanced superconductors, including the low-temperature superconductor Nb_3Sn and the high-temperature superconductor $REBa_2Cu_3O_{7-x}$ (RE = Rare Earth, REBCO). Over the last two decades the transport current at high field of the most advanced multifilamentary Nb_3Sn conductors has more than doubled, and the filament size reduced, resulting in high-performance conductors that are stable at the low fields of relevance to superconducting undulators (SCUs). These developments are the result of a strong, longstanding commitment by the High Energy Physics community to work with and support the conductor industry. This is particularly true in the US, where for decades the DOE-OHEP has supported a conductor development program and has hosted a yearly workshop devoted to conductor advances and coordination between industrial conductor manufacturers and magnet applications. Modern Nb_3Sn "RRP" conductors transport current with impressive current densities — exceeding J_E(4.2K,4T)=2000A/mm^2 — yielding undulator performance significantly beyond that of traditional permanent-magnet based undulators in certain period/gap regimes. In parallel over the last 5 years there have been significant improvements in REBCO "tape" conductor performance, both through enhancement of low-field flux pinning via Zr doping and via reduction in substrate thickness, making them viable candidates for undulator technology as well.

Here we summarize superconductor characteristics critical for undulator applications, including issues such as magnetization and AC losses, and provide a review of current state of the art conductor performance. Routes for further advances in conductor performance are described, and examples of current research in those areas provided. We then review SCU concepts, first describing the basic planar and helical topologies and critical technical considerations associated with each. The issue of field quality and its correction in SCUs is discussed. Results from a 1.5m Nb_3Sn prototype designed and fabricated at LBNL as part of a SLAC/ANL/LBNL collaboration are described, including magnet training behavior, measured field quality, and demonstrated field quality correction. Finally, technology hurdles that must be overcome for large scale application of SCU technology to light sources are discussed.

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