Electromagnetic Modeling Of HTS Superconductors - A Benchmark Collection

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Abstract

Superconductors are increasingly used in a variety of systems, including MRI systems, particle accelerators, nuclear fusion reactors, superconducting electronics, and even superconducting electrical machines. Modeling superconductors involves several challenges, such as the resistivity varying extremely nonlinearly with temperature, current, and magnetic field, as well as thin layers and stacks thereof, in high-temperature superconductor cables wound in intricate geometries, such as stellarator coils. To address these challenges, various specific electromagnetic formulations and couplings have been proposed in the literature, including the H, H-Phi, T-A, and homogenized T-A formulations, among others.

In this work, a collection of 12 models using and comparing the above formulations has been reviewed and documented in COMSOL 6.3. The applications include passive bulk superconducting disks and rings, as well as multiple solid and thin filaments carrying transport currents, in the absence and presence of external magnetic fields. The most complex models incorporate two-layer CORC® cables and non-planar coil systems for a stellarator fusion reactor, utilizing sophisticated periodicity or homogenization approaches.

The collection of benchmark models can serve as a reference for the usage of many COMSOL modeling features typically encountered in the HTS community and a foundation for even more complex models in the future.

Figures used in the abstract

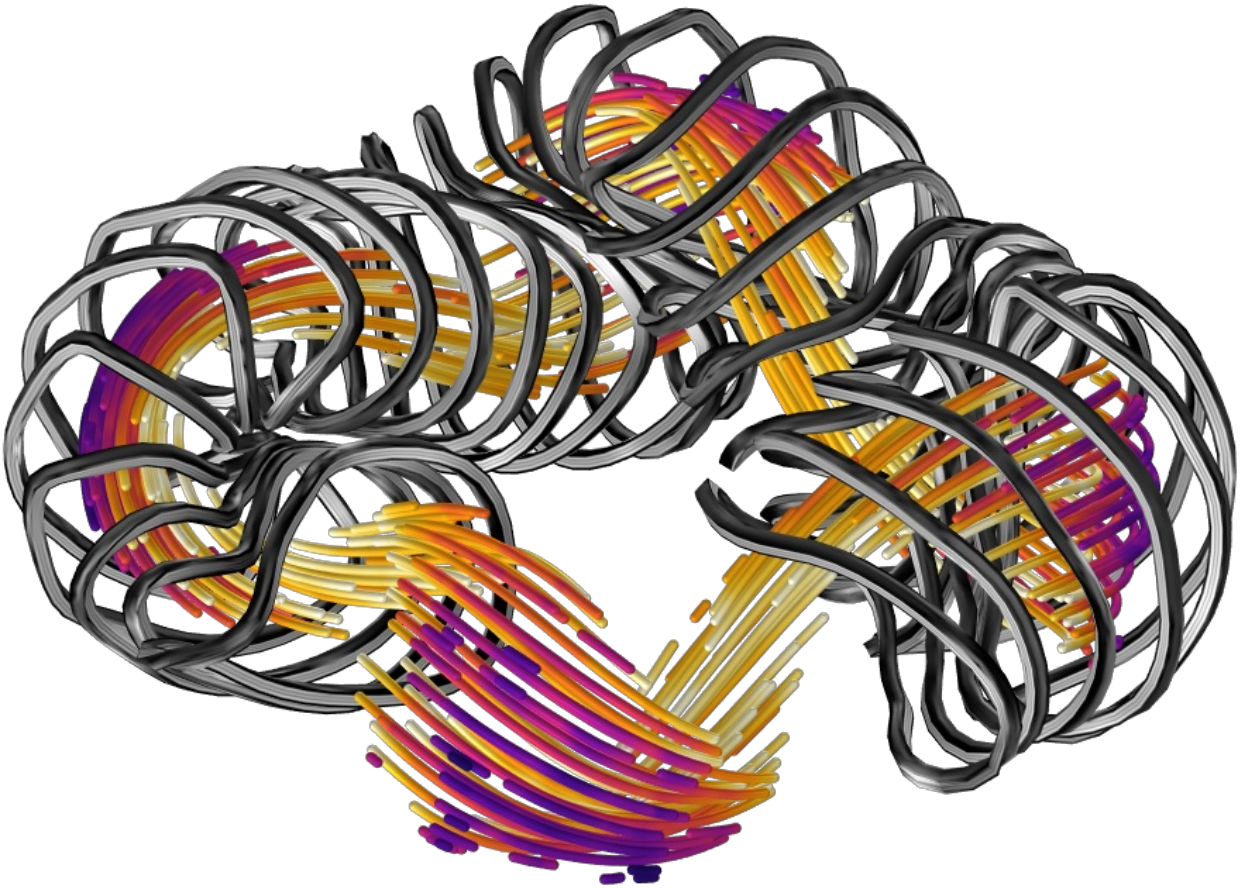

Figure 1 : Non-planar HTS coil system of a stellarator fusion reactor modeled using the homogenized T-A formulation.