Experimental validation of a new HPC modelling tool for High Temperature Superconductivity

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Superconductivity is a physical phenomenon of some materials that allows them to conduct electrical current without resistance. This property has many established applications which can be enhanced by considering different superconducting materials. In particular, some Type-II High Temperature Superconductors (HTS) are promising for building strong electromagnets or carrying large amounts of current in extreme conditions like those in possible future fusion reactors. However, both its manufacturing and related experiments are highly expensive and challenging. Predicting accurately and efficiently the magnetic response of High Temperature Superconductors is of high importance in numerous applications such as energy transport and storage, trapped-field magnets, or magnetic shielding.

Here, we present a novel contribution to achieve a multiphysics tool able to simulate accurately HTS devices. Our approach is based on `magnet`, an electromagnetic module of the HPC code *Alya* developed in the Barcelona Supercomputing Center. A first experimental validation of this module has been recently completed by reproducing experimental measurements on HTS tapes carried out at ICMAB (Institute of Materials Science of Barcelona).

Our results indicate that `magnet` could be used for 2D and 3D simulations of an HTS tape, both with a good agreement with the experimental data. However, it was not able to reproduce minor asymmetries in the vertical magnetic field component observed in the experiments. New implementations have been added in the code in order to introduce a field-dependent Critical Current on the superconducting tape. Finally, we could show that 3D simulations achieved slightly better results than the 2D cases. Overall, there are no fundamentally different results between the simulations and all of them showed good agreement with experimental data.

Our results demonstrate how Alya and its `magnet` module can simulate accurately an HTS experiment. With further validations and upgrades, it is expected to become a useful multiphysics tool to simulate challenging phenomena (e.g. *Quench*) in complex HTS cabling configurations for Fusion.