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High-performance simulation of the magnetic field in superconducting magnets using domain decomposition algorithms in the Sparselizard open source FEM library

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To get an understanding of the magnetic field distribution in a superconducting magnet, computer simulations are needed which take into account the actual geometry of the magnet and the magnetic saturation in different materials. It is a further advantage that the software efficiently tackles the large number of unknowns needed for accurate 3D simulations and also allows the coupling of additional physics of interest (e.g. thermo-electricity for quench propagation, mechanics).
In this work we demonstrate the capabilities of a free, open source multiphysics FEM software to predict the magnetic field created in CERN's Feather-M2 particle accelerator dipole magnet model as well as the magnetically induced mechanical stresses. Tools adapted for efficient 3D magnetic field simulations are used: a vector potential formulation is solved with edge shape functions and a spanning-tree gauging technique. A high performance domain decomposition algorithm is used to dramatically speed-up the heavy computation. The simulation performed in this paper is provided in an online example to the magnet designer community. Additional physics for thermo-electric simulations of quench propagation or mechanical simulations can be coupled to this example in a straightforward way within the same software.

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