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Nonlinear magnetic field analysis in superconducting accelerator magnets via a new FPM/BEM scheme, implemented in PITHIA-EM software

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An advanced hybrid numerical method for the solution of nonlinear magnetostatic problems in superconducting accelerator magnets is proposed. The methodology is implemented in PITHIA-EM software and couples the Fragile Points Method (FPM) with the Boundary Element Method (BEM). The FPM is a Galerkin-type meshless method, based on a Discontinuous Galerkin weak form where simple, local, and discontinuous point – based interpolation functions are employed for field approximation. The local discontinuity inconsistencies, due to the discontinuity of these functions, are treated via numerical flux corrections. The FPM combines the advantages of mesh-free methods and the Finite Element Method (FEM) utilizing, however, fewer nodal points than the FEM for the solution of the same problem. On the contrary, the BEM is an efficient methodology in solving linear problems with high volume to surface ratio. In the present study, the nonlinear behavior of the ferromagnetic yoke in an accelerator magnet is treated by the FPM, while the BEM is employed for the infinitely extended, surrounding air space. The source magnetic field produced by the superconducting coils is calculated with high accuracy via a Biot –Savart integral. The FPM/BEM methodology is described and implemented for scalar and vector potential formulations. The efficiency of the method is demonstrated through representative nonlinear magnetostatic problems appearing in accelerator magnets.

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