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# Electromagnetic Simulations in MOOSE using the MFEM Finite Element Library

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The ability to generate actionable qualification data by modelling the coupled multiphysics of components with complex geometries in fusion-relevant environments is required in order to de-risk candidate component designs prior to installation in fusion devices. Such models demand the use of highly scalable tools on HPC systems, capable of solving coupled problems consisting of billions of degrees of freedom in parallel, without imposing excessive licensing costs for end users.

In this talk, we shall present recent capabilities added to the open-source MOOSE framework [1] for the simulation of coupled large-scale electromagnetics problems, enabled via the integration of the MFEM finite element library [2]. Such capabilities include the use of arbitrary order vector-valued finite element types spanning the de Rham complex, the use of complex variables and integrators, and support for problem set-up, assembly, and solution on CPU or GPU architectures. We shall demonstrate the application of these new capabilities in solving magnetostatic and magnetodynamic problems in both the time and frequency domain, and report on our ongoing work extending these capabilities to nonlinear scenarios.

[1] Harbour, L., Giudicelli, G., Lindsay, A. D., et al.; 4.0 MOOSE: Enabling massively parallel Multiphysics simulation, Journal of Software X, 31, (2025)

[2] Anderson, R. Andrej, J., Barker, A. et al.; MFEM: A modular finite element methods library, Computers & Mathematics with Applications, 81, (2021)

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