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TOWARDS A 3D MAGNETO-MECHANICAL SOFTWARE USING *hp*-FINITE ELEMENTS FOR MRI SCANNER DESIGN

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Magnetic resonance imaging (MRI) is a diagnostic tool available to medical practitioners in most major medical centres used for the detection of tumours, neuroimaging and for the diagnosis of many other medical conditions. MRI scanners utilise a set of superconducting coils to generate a uniform strong magnetic field, and a set of gradient coils to produce pulsed field gradients in order to generate an image. These gradient fields give rise to eddy currents in conducting components, which leads to the generation of Lorentz forces causing these components to deform and vibrate. These vibrations have undesirable effects such as imaging artefacts, patient discomfort and cooling helium boil-off.

The aim of this project is to develop a computational tool to accurately solve this coupled magneto-mechanical problem and aid the design of new MRI scanners. We focus on the solution for realistic 3D configurations and apply *hp*-finite elements to ensure accurate solutions, extending the group's previous work on axisymmetric geometries [1].

The solution of 3D problems presents significant challenges compared to the axisymmetric approach. The talk will describe the sets of $H(\text{curl})$ and H^1 conforming finite element basis functions for describing the electromagnetic and mechanical fields, respectively. The approach taken to solve the large sparse complex linear system of equations using a block Jacobi preconditioner and GMRES solver will also be discussed. The talk will include numerical examples and comparisons with the group's previous approach [1]. The presentation will also include details of how this 3D solver will be used as an off-line stage in a PGD approach for the rapid prediction of outputs of interest for MRI scanner design.

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REFERENCES

[1] S. Bagwell, P.D. Ledger, A.J. Gil, M. Mallett, M. Kruip. *A linearised hp-finite element framework for acousto-magneto-mechanical coupling in MRI scanners*. Int. J. Numer. Meth. Eng., Vol. 112, pp. 1323-1352, 2017.