# Proper generalised decomposition for coupled magneto-mechanical problems with application to MRI scanners

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## ABSTRACT

Magnetic resonance imaging (MRI) is often the preferred choice regarding medical imaging due to its non-intrusive nature and its high performance when imaging soft tissues such as damaged cartilage, fractures, joints and tumour detection. Time varying magnetic fields are used as part of the imaging process, but these also cause unwanted eddy currents in the conducing shields. This in turn, generates field perturbations and mechanical stresses in the shields. The deformation of the shields can generate noise and cause the generation of Lorentz currents, which further perturb the fields and also cause Ohmic heating. The associated noise can cause patient discomfort, the field perturbations can reduce image quality. The heating leads to helium boil-off and can lead to magnet quench. In [1] a computational framework for the simulation of such problems has been proposed (full order model).

In order to improve the computational efficiency of obtaining outputs during the design stage of an MRI scanner where rapid investigation of the response for different input parameters is desired, the proper generalised decomposition (PGD) [2] has been applied and implemented for coupled magneto-mechanical problems. This methodology allows the obtention of a high-order parametric solution that takes into account extra material and geometrical parameters.

A regularised-adaptive PGD [3] has been developed in order to circumvent the numerical difficulties associated with the ill-conditioning of the system near resonant modes. In the presentation, this regularised-adaptive PGD will be presented including three extra parameters and we will show that we are able to drastically reduce the computational cost whilst maintaining the same level of accuracy as in the full order model.

## REFERENCES

[1] S. Bagwell, P.D. Ledger, A.J. Gil, M. Mallet and M. Kruip. A linearised *hp*-finite element framework for acousto-magneto-mechanical coupling in axisymmetric MRI scanners. *Int. J. Num. Meth. Engng.*, Vol 112(10), pp. 1323-1352, 2017.

[2] D. Modesto, S. Zlotnik and A. Huerta. Proper generalised decomposition for parametrized Helmholtz problems in heterogeneous and unbounded domains: Application to harbour agitation. *Comput. Method. Appl. Mech. Engng.*, Vol 295, pp. 127-149, 2015.

[3] G. Barroso, A.J. Gil, P.D. Ledger, M. Mallet, A. Huerta. A regularised-adaptive proper generalised decomposition for coupled magneto-mechanical problems with application to MRI scanners. In preparation.