ISOGEOMETRIC ANALYSIS IN PLASMA PHYSICS AND ELECTROMAGNETISM

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In this work, we will present some applications of the *IGA* approach in Plasma Physics simulation and electromagnetism, specially the time domain problem. To this purpose, we have developed a Python library, namely *PyIGA*.
In many problems in Plasma Physics, e.g. applications in the ITER project, we must deal with the complexity of the tokamak geometries. IGA seems to be an excellent approach to treat these problems. We have studied the gyrokinetic quasi-neutrality equation, [3], and also some MHD equilibrium problems.
For the Maxwell time domain problem, we developed, [2], a new formulation of the exact sequence of Finite Element spaces based on splines, introduced by Buffa et al. [1], having the same properties as the Whitney Finite Element spaces traditionally used for the Finite Element solution of Maxwell's equations. As with the Whitney elements, one of Amperes or Faradays law can be discretized with a relation between the spline coefficients of the electric and magnetic fields independent of the topology of the mesh. The metric comes in through a discrete Finite Element Hodge operator which appears as the mass matrix involved in the other equation. This method allows us to inverse only one matrix at each time step.
We propose also a new strategy [4], namely the Fast IGA approach, specific to a large variety of domains, to solve some important problems: Maxwell's equations, current-hole problem, evolution pde's, and more generally any problem where we need to inverse the mass matrix at each time step. In Figure 1, we present the typical CPU time needed for the Poissons equation on a ring domain.

	Initializing			Solving	
p	*FIGA*	*SPLU*		*FIGA*	*SPLU*
1	0.021	3.38		0.074	0.067
2	0.043	31.40		0.076	0.967
3	0.052	197.31		0.075	3.505
4	0.060	330.28		0.075	16.070
5	0.069	415.63		0.077	32.852

Figure 1: CPU-time, in seconds, spent in initializing (left) and solving (right) the linear system, using the new approach, namely Fast IGA, compared to SuperLU. Test done on a grid 256×256

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