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A Fast Multipole Method based Grad-Shafranov solver ANTOINE CERFON, TRAVIS ASKHAM, Courant Institute, NYU, ZYDRUNAS GIMBUTAS, National Institute of Standards and Technology, JUNGPYO LEE, LESLIE GREENGARD, Courant Institute, NYU — We present a fast, high order accurate, adapative Grad-Shafranov solver for complex plasma geometries with or without X-points. The solver uses two main ingredients: 1) the reformulation of the Grad-Shafranov equation as a nonlinear Poisson problem; 2) a fast Poisson solver based on integral equation methods. To be more specific regarding the second ingredient, the solution of Poisson's equation is written as the sum of a volume potential and a double layer potential. The volume potential is calculated in optimal time with the Fast Multipole Method (FMM), and the layer potential is computed using high order quadrature techniques. Beside its speed, this new solver has two properties that make it a desirable option for transport, heating, or stability codes that require coupling with an equilibrium solver. First, the solver automatically refines the mesh in regions of steep gradient, such as the edge pedestal. Second, the integral equation formulation does not only lead to high order accuracy for the solution of the Grad-Shafranov equation, but also for its derivatives. This means that the safety factor and the magnetic shear, among other quantities, can be computed with very good accuracy.

Antoine Cerfon
Courant Institute, NYU

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