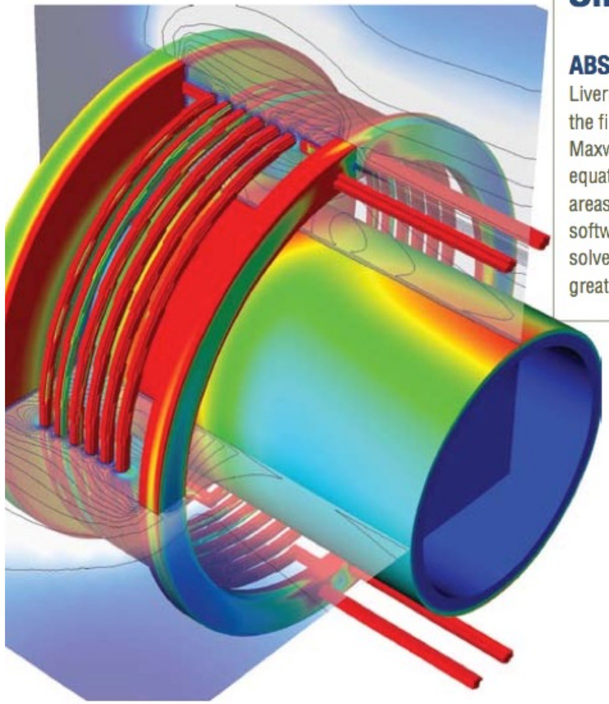
Novel Solver Enables Scalable Electromagnetic Simulations

ABSTRACT: A team based at Lawrence Livermore National Laboratory has developed the first provably scalable solver code for Maxwell's equations, a set of partial differential equations that are fundamental to numerous areas of physics and engineering. This new software technology enables researchers to solve larger computational problems with greater accuracy.



AMS computation of a bifilar helical coil problem used in pulsed-power experiments.

Image courtesy R.N. Rieben, LLNL.

Large-scale electromagnetic simulations are often bottlenecked by slow linear solvers. In simulations conducted at LLNL, a newly developed algorithm, known as the auxiliary-space Maxwell solver (AMS), outperforms earlier solution techniques by as much as 25 times, giving researchers a significant advantage in the future as the questions they seek to answer inevitably become larger and more complex.

The solver's capability is the result of its scalability. Specifically, AMS exhibits "weak" parallel scalability, meaning that the solution time is constant as the problem size and processor workload simultaneously increase. The new algorithm is able to handle complex geometries and problems with large jumps in the material coefficients. In contrast some of the old solvers take more time and produce less accurate results when faced with systems that consist of materials of widely different electromagnetic properties, which are common in engineering.

AMS works by reducing the original problem to a series of equations that can be individually handled using classical techniques. A major advantage of this approach is that its performance is backed by a solid theoretical framework. Thus, AMS is a perfect example of how fundamental mathematical research can lead to important software advances in HPC. In this effort Panayot Vassilevski and Tzanio Kolev of LLNL collaborated with Jinchao Xu of Penn State University and Ralf Hiptmair of ETH, Zurich.

Electromagnetic simulations have a wide range of physical and engineering applications such as in the development of semiconductor chips, stealth aircraft, and electrical generators. As the ability of supercomputers to tackle ever bigger problems grows, researchers need to be able to efficiently take advantage of this newfound computing power.

The AMS solver does just that, solving ever more complex simulations with greater accuracy. It gives researchers an edge by taming solution time, which enables a greater number of simulations,

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