数学与系统科学研究院

计算数学所学术报告

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报告题目**：**

Numerical solution of the time-harmonic Maxwell equations and incompressible magnetohydrodynamics problems

邀请人**：**　　白中治研究员

报告时间**：2011** 年 **2** 月 **28** 日（周一）

下午 **15：30-16：30**

报告地点**：**　　科技综合楼三层 **311**

计算数学所报告厅

Abstract：

We are interested in developing efficient numerical solvers for the time-harmonic Maxwell equations and for incompressible magnetohydrodynamics problems. Our work consists of three components. In the first part, we present a fully scalable parallel iterative solver for the time-harmonic Maxwell equations in mixed form with small wave numbers. We use the lowest order Nedelec elements of the first kind for the approximation of the vector field and standard nodal elements for the Lagrange multiplier associated with the divergence constraint. The corresponding linear system has a saddle point form, with inner iterations solved by preconditioned conjugate gradients. We demonstrate the performance of our parallel solver on problems with constant and variable coefficients with up to approximately 40 million degrees of freedom. Our numerical results indicate very good scalability with the mesh size, on uniform, unstructured and locally refined meshes. In the second part, we introduce and analyze a mixed finite element method for the numerical discretization of a stationary incompressible magnetohydrodynamics problem, in two and three dimensions. The velocity field is discretized using divergence-conforming Brezzi-Douglas-Marini (BDM) elements and the magnetic field is approximated by curl-conforming Nedelec elements. Key features of the method are that it produces exactly divergence-free velocity approximations, and that it correctly captures the strongest magnetic singularities in non-convex polyhedral domains. We prove that the energy norm of the error is convergent in the mesh size in general Lipschitz polyhedra under minimal regularity assumptions, and derive nearly optimal a-priori error estimates for the two-dimensional case. We present a comprehensive set of numerical experiments, which indicate optimal convergence of the proposed method for two-dimensional as well as three-dimensional problems. Finally, in the third part we investigate preconditioned Krylov iterations for the discretized stationary incompressible magnetohydrodynamics problems. We propose a preconditioner based on efficient preconditioners for the Maxwell and Navier-Stokes sub-systems. We show that many of the eigenvalues of the preconditioned system are tightly clustered, and hence, rapid convergence is accomplished. Our numerical results show that this approach performs quite well.

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