VI International Conference on Adaptive Modeling and Simulation
ADMOS 2013
J. P. Moitinho de Almeida, P. Díez, C. Tiago and N. Parés (Eds)

ADAPTIVE SPACE-TIME FINITE ELEMENT METHOD FOR A NONLINEAR EVOLUTIONARY MONOTONE PROBLEM FROM APPLIED SUPERCONDUCTIVITY

A. WAN*, M. LAFOREST* AND F. SIROIS†

*Département de mathématiques et génie industriel
École Polytechnique de Montréal
C.P. 6079, succursale centre-ville
Montréal, QC, Canada, H3C 3A7
e-mail: andy.wan@polymtl.ca, marc.laforest@polymtl.ca

†Département de génie électrique
École Polytechnique de Montréal
C.P. 6079, succursale centre-ville
Montréal, QC, Canada, H3C 3A7
e-mail: f.sirois@polymtl.ca

Key words: adaptivity, error estimation, space-time, finite element method, Maxwell's equations, nonlinear parabolic PDE, superconductivity

Abstract. The steady improvement of the performances of high temperature superconductors (HTS) brings them within reach of new applications, such as HTS motors, transformers and fault current limiters. To optimize the design of these devices, one must be able to predict the magnetic and electric fields in complex 3-D geometries, but doing so efficiently and accurately is still a challenging task. Within the engineering community, phenomenological models relating the electric field and current density of HTS lead to a novel nonlinear evolutionary monotone PDE based on Maxwell's equations, which is effectively a generalization of the classical p-Laplacian problem. Unfortunately, these models possesses sharp moving fronts that lead to the use of prohibitively small time steps in numerical simulations, even in 2-D domains.

In this work, we propose a new numerical space-time method that allows for local space and time adaptivity without the restrictive global timestep constraint. We present an a posteriori error estimator for the computation of the AC loss, a key design parameter for HTS devices. Numerical results are presented in one and two space dimensions attesting to the efficiency of the numerical method.