Fynn Scheben
Iterative methods for neutron transport eigenvalue problems

Department of Mathematical Sciences
University of Bath
Bath
BA2 7AY
United Kingdom
F.Scheben@bath.ac.uk
Ivan G. Graham

We discuss iterative methods for computing criticality in nuclear reactors. In general this requires the solution of a generalised eigenvalue problem for an unsymmetric integro-differential operator in 6 independent variables, modelling transport, scattering and fission, where the dependent variable is the neutron angular flux. In engineering practice this problem is often solved iteratively, using some variant of the inverse power method. Because of the high dimension, matrix representations for the operators are often not available and the inner solves needed for the eigenvalue iteration are implemented by matrix-free inner iterations. This leads to technically complicated inexact iterative methods, for which there appears to be no published rigorous convergence theory. For the monoenergetic homogeneous model case with isotropic scattering and vacuum boundary conditions, we show that the general nonsymmetric eigenproblem for the angular flux is equivalent to a certain related eigenproblem for the scalar flux, involving a symmetric positive definite weakly singular integral operator (in space only). This correspondence to a symmetric problem (in a space of reduced dimension) permits us to give a convergence theory for inexact inverse iteration and related methods. In particular this theory provides rather precise criteria on how accurate the inner solves need to be in order for the whole iterative method to converge. The theory is illustrated with numerical computations on a homogeneous benchmark problem from the Los Alamos test set and also on an inhomogeneous bienergetic control rod problem, using GMRES as the inner solver.