

Contents

General Index	VII
List of Figures	XI
List of Tables	XVII
1 Introduction	1
1.1 Neutron diffusion equation	2
1.2 Lambda Modes equation	13
1.3 VVER Reactors	14
1.4 Spectral Element Methods (SEM)	19
2 Spectral Element Method for the Neutron Diffusion Equation	23
2.1 One-dimensional geometries	24
2.1.1 Spectral Element Methods	26
2.1.2 Numerical results	35
2.2 Two- and three-dimensional geometries	41
2.2.1 Variational Formulation	43
2.2.2 Reference element	46
2.2.3 Polynomial basis	48
2.2.4 Building the matrices	52
2.2.5 Algebraic problem	55
2.2.6 Numerical Results	56

3 Time Dependent Neutron Diffusion Equation	81
3.1 Backward Method	82
3.1.1 Time discretization	83
3.1.2 Rod cusping	85
3.1.3 Numerical results	87
3.2 Block Preconditioning	94
3.2.1 Solvers for the linear systems	96
3.2.2 Numerical Results	99
3.3 Spectral Preconditioning	104
3.3.1 Spectral Preconditioner	105
3.3.2 Numerical Results	106
3.4 Exponential Method	111
3.4.1 Exponential operator and its Magnus Expansion	112
3.4.2 Implementation of the product matrix exponential - vector	120
3.4.3 Numerical Results	125
4 Updating Eigenvalue Methods	127
4.1 Modified Block Newton Method	128
4.1.1 Spatial discretization	129
4.1.2 Modified Block Newton Method	133
4.1.3 Numerical Results	135
4.2 Alternative Newton Methods	146
4.2.1 Modified Block Newton Method	147
4.2.2 One Sided Block Newton Method	148
4.2.3 Two Sided Block Newton Method	148
4.2.4 Numerical Results	149
4.3 Proper Generalized Decomposition for eigenvalue computations	153
4.3.1 Eigenvalue problem	157
4.3.2 Numerical Results	161
5 Conclusions	165
A Special Functions	171
A.1 Legendre polynomials	172
A.2 Associated Legendre functions	173

A.3 Spherical Harmonics	175
A.4 Relations	176
B Evaluation of the polynomials and the integrals	181
B.1 Evaluation of the modified Dubiner's polynomials	181
B.2 Evaluation of the integrals by means of quadrature rules	182
Bibliography	185