1 Runge–Kutta (–Nyström) Methods for Oscillatory Differential Equations ........................................ 1
  1.1 RK Methods, Rooted Trees, B-Series and Order Conditions .......... 1
  1.2 RKN Methods, Nyström Trees and Order Conditions ............... 8
    1.2.1 Formulation of the Scheme .................................. 8
    1.2.2 Nyström Trees and Order Conditions ....................... 9
    1.2.3 The Special Case in Absence of the Derivative ............. 18
  1.3 Dispersion and Dissipation of RK(N) Methods ..................... 19
    1.3.1 RK Methods .................................................. 20
    1.3.2 RKN Methods ................................................ 21
  1.4 Symplectic Methods for Hamiltonian Systems ...................... 22
  1.5 Comments on Structure-Preserving Algorithms for Oscillatory Problems ........................................... 23
References ...................................................................... 24

2 ARKN Methods .......................................................... 27
  2.1 Traditional ARKN Methods .......................................... 27
    2.1.1 Formulation of the Scheme ...................................... 28
    2.1.2 Order Conditions ................................................. 29
  2.2 Symplectic ARKN Methods .......................................... 32
    2.2.1 Symplecticity Conditions for ARKN Integrators ............ 33
    2.2.2 Existence of Symplectic ARKN Integrators ................. 37
    2.2.3 Phase and Stability Properties of Method SARKN1s2 ....... 41
    2.2.4 Nonexistence of Symmetric ARKN Methods ............... 43
    2.2.5 Numerical Experiments ......................................... 44
  2.3 Multidimensional ARKN Methods .................................... 48
    2.3.1 Formulation of the Scheme ...................................... 48
    2.3.2 Order Conditions ................................................. 52
    2.3.3 Practical Multidimensional ARKN Methods ............... 57
References ...................................................................... 60
### 3 ERKN Methods

#### 3.1 ERKN Methods
- Formulation of Multidimensional ERKN Methods
- Special Extended Nyström Tree Theory
- Order Conditions

#### 3.2 EFRKN Methods and ERKN Methods
- One-Dimensional Case
- Multidimensional Case

#### 3.3 ERKN Methods for Second-Order Systems with Variable Principal Frequency Matrix
- Analysis Through an Equivalent System
- Towards ERKN Methods
- Numerical Illustrations

### 4 Symplectic and Symmetric Multidimensional ERKN Methods

#### 4.1 Symplecticity and Symmetry Conditions for Multidimensional ERKN Integrators
- Symmetry Conditions
- Symplecticity Conditions

#### 4.2 Construction of Explicit SSMERKN Integrators
- Two Two-Stage SSMERKN Integrators of Order Two
- A Three-Stage SSMERKN Integrator of Order Four
- Stability and Phase Properties of SSMERKN Integrators

#### 4.3 Numerical Experiments

#### 4.4 ERKN Methods for Long-Term Integration of Orbital Problems

#### 4.5 Symplectic ERKN Methods for Time-Dependent Second-Order Systems
- Equivalent Extended Autonomous Systems for Non-autonomous Systems
- Symplectic ERKN Methods for Time-Dependent Hamiltonian Systems

#### 4.6 Concluding Remarks

### 5 Two-Step Multidimensional ERKN Methods

#### 5.1 The Scheifele Two-Step Methods

#### 5.2 Formulation of TSERKN Methods
- Order Conditions
- B-Series on SENT
- One-Step Formulation
- Order Conditions

#### 5.3 Construction of Explicit TSERKN Methods
- A Method with Two Function Evaluations per Step
- Methods with Three Function Evaluations per Step

#### 5.5 Stability and Phase Properties of the TSERKN Methods
Appendix  First and Second Symposiums on Structure-Preserving Algorithms for Differential Equations, August 2011, June 2012, Nanjing .................................................. 231
Index ................................................................. 233
Structure-Preserving Algorithms for Oscillatory Differential Equations
Wu, X.; You, X.; Wang, B.
2013, XII, 236 p. 40 illus., 2 illus. in color., Hardcover
ISBN: 978-3-642-35337-6