Monte Carlo Method for Solving Inverse Problems of Radiation Transfer

V.S. Antyufeev
Contents

Chapter 1. Monte Carlo modifications for solving problems of radiation transfer
1.1. Elements of using the Monte Carlo method in radiation transfer computation 1
1.2. The "conjugate" computation scheme 5
1.3. Use of the importance function 6
1.4. Method of mathematical expectation for plane slab model 7
1.5. Improvement of the method of mathematical expectation 15
1.6. Modification of the distribution of particle path length 18
1.7. Modification of the trajectory angular distribution 20
1.8. Modification of radiation transfer modelling in spherical atmosphere 26
   1.8.1. Statement of the problem 26
   1.8.2. Computational algorithm 27

Chapter 2. Generalized transport equation with highly peaked phase function
2.1. Generalized transport equation 31
2.2. Approximation for highly peaked phase function 34
2.3. Transformation of standard transport equation 36
2.4. Optimizing procedures for modelling and calculation 37
   2.4.1. Modification of the local estimate 38
   2.4.2. Modification of trajectory modelling 40
   2.4.3. Modifications of the calculation of the radiation flux 44
6.4. Taking into account the hot spot effect ........................................ 111
6.5. Statement of the inverse problem and an algorithm of
    its solution .............................................................................. 112
6.6. Evaluation of derivatives by the Monte Carlo method ............... 114
6.7. On estimating the leaf-normal distribution for a plant canopy .... 116
    6.7.1. Iterative method ............................................................... 117
    6.7.2. On calculating the integrals A, B and C ............................. 120
6.8. Numerical results ...................................................................... 122
6.9. Synopsis .................................................................................. 125

Chapter 7. X-ray tomography in scattering media ......................... 127
7.1. Mathematical background ......................................................... 129
7.2. The general scheme of the method .......................................... 134
    7.2.1. Design and arrangement of the detectors ......................... 134
    7.2.2. Step 1: Reconstruction of the extinction coefficient
            distribution ........................................................................... 135
    7.2.3. Step 2: Reconstruction of the scattering coefficients .......... 136
    7.2.4. Step 3: Reconstruction of the absorption coefficient
            distribution ........................................................................... 139
7.3. Numerical results ...................................................................... 139
    7.3.1. Computing the jumps of the first and the second kind ....... 140
    7.3.2. Scattering effect on body image reconstruction ................. 142
7.4. Conclusions .............................................................................. 142

Appendix A. Integral equation of the second kind with
    stochastic kernel ........................................................................ 145
A.1. Introduction ............................................................................ 145
A.2. Decomposition of the solution ................................................. 146
A.3. Numerical method for solving the equation ............................... 148
A.4. Numerical examples ................................................................ 151

Appendix B. Computation of radiation field in optically
    thick medium by the Monte Carlo method ................................. 155
B.1. Introduction ............................................................................ 155
B.2. Transformation of the transport equation ................................. 156
B.3. Illustrative study of the method ............................................... 163