Mathematical Modeling of Polarized-radiation Transfer and its Applications in Computer Tomography

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Abstract: The basic model for the description of photon transfer processes is given by linear integro-differential Boltzmann equation. Within the framework of this model, two types of photon interaction with substance are considered, one being absorption, and the other, scattering. Both processes substantially depend on the polarization of the incident radiation. To provide for more accurate description of the transfer process, the vector transfer equation for polarized radiation is considered. The main directions of our investigations are the following:

1. Theoretical aspects of the solution of the vector transfer equation.
The general properties of the solution of the direct problem are examined. In particular, solution continuity properties, presentation conditions of solution throw Neumann series and the convergence conditions for these series are investigated.

2. An inverse problem for vector transfer equation in isotropic medium.
In the problem, it is required to find the attenuation factor from known solution of the equation at the medium boundary. The method for determining this factor is based on using an external-radiation source of special type with ordinary discontinuity. A formula is derived that relates the Radon transform of the attenuation factor with the radiation flux density at the boundary. The uniqueness theorem of the solution of the tomography problem is proved.

3. Boundary problem for polarized-radiation transfer equation in layered medium.
The boundary problem for vector transfer equation in layered medium with general matching conditions of solution describing the reflection-refraction at the boundaries of medium division is considered. Continuity properties of the boundary problem solution are investigated. Theorems of boundary problems solubility for polarized-radiation transfer equation in layered medium and estimates of maximum principle type were obtained. Numerical algorithm for solving the boundary problem was developed.

4. Optical computer tomography of layered medium.
The problem of finding of refractive index and optical depth of layered medium is investigated. We proposed the algorithm for solving this problem. The approach is based on using an external-radiation source of special type. Uniqueness conditions of the inverse problem solution are formulated.

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