Numerical Simulations of a Coupled Conductive-Radiative Heat Transfer Model

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Abstract: Conductive-radiative heat transfer in a medium bounded by two reflecting and radiating plane surfaces is considered. This process is described by a nonlinear system of two differential equations: an equation of the radiative heat transfer and an equation of the conductive heat exchange. The problem is characterized by anisotropic scattering of the medium and by specularly and diffusely reflecting boundaries.

An iterative algorithm for solving this problem is considered. For the calculation of solutions of the radiative transfer equation, a recursive algorithm based on some modification of the Monte Carlo method is used. This algorithm is well parallelizable, and hence it can provide a good accuracy within a reasonable computing time.

Compared with P_N approximations, the algorithm proposed allows us to obtain more precise results, because it deals with the exact model, whereas P_N approximations utilize simplified transfer equations. Compared with the method of discrete ordinates, the modified Monte Carlo algorithm is well appropriate for parallelization, because trajectories can be randomly generated independently on each other, and additionally parallelization over points of the layer in which the normalized temperature is calculated can easily be implemented. Thus, the development of multiprocessor systems will provide the permanently growing speedup of the modified Monte Carlo algorithm so that it expects to show a good performance in complicated cases, in particular, for thee dimensional problems.

Exemplary simulations based of the method proposed are done on a computer cluster of the Technical University of Munich. The case of isotropic scattering and reflecting boundaries was considered. The comparison of our results with known numerical data is presented.

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