# Comparison of parallel implicit solvers for the model kinetic equations

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The development of new technologies requires the creation of numerical methods for the simulation of three-dimensional rarefied gas flows in various microscopic devices. One of such methods is the direct numerical solution of the kinetic equation for the velocity distribution function. Most of the existing approaches use explicit difference schemes on multi-block meshes in physical space [1-2]. An explicit method is relatively simple for computer implementation, but requires excessive computing times for calculation of steady flows by time marching. In [3-4] an implicit single-block method for model kinetic equations was developed, which is free of this weakness. The main parts of the method are a non-oscillatory TVD method on hybrid unstructured meshes, conservative procedure for calculation of macroscopic parameters of the gas and fully implicit one-step time evolution method without iterations on the upper time level. The parallel implementation of the method uses the partitioning of the molecular velocity mesh, which allows one to keep all the advantages of the implicit method of solution.

Despite its advantages, the parallel method based on the partitioning of the velocity mesh will have restrictions on the size of the spatial mesh on the most of the existing HPC systems. The conventional approach with multi-block spatial meshes is free of such limitations. However, the direct extension of the implicit time marching method to arbitrary multi-block meshes encounters serious difficulties from both the algorithmic part and in maintaining good parallel scalability of the code. The main goal of the present work is to analyze the multi-block version of the implicit scheme [3-4], not using the data exchange between blocks during the solution of the linear system of equations for the solution increments in the implicit scheme. The resulting parallel method is not strictly equivalent to the single block method. The analysis is based on various calculations for the problem of rarefied gas flow through a circular pipe caused by the pressure drop [5,6] as well as external supersonic flow over a model re-entry vehicle VKS TsAGI. The studies are focuses on the influence of the number of blocks as well as choice of the time step on the convergence to the steady solution. The strong scalability of both versions of the parallel method is also investigated.

List of references

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