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Mathematical Physics

Towards an ultra efficient kinetic scheme. Part I: basics on the BGK equation

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In this paper we present a new ultra efficient numerical method for solving kinetic equations. In this preliminary work, we present the scheme in the case of the BGK relaxation operator. The scheme, being based on a splitting technique between transport and collision, can be easily extended to other collisional operators as the Boltzmann collision integral or to other kinetic equations such as the Vlasov equation. The key idea, on which the method relies, is to solve the collision part on a grid and then to solve exactly the transport linear part by following the characteristics backward in time. The main difference between the method proposed and semi-Lagrangian methods is that here we do not need to reconstruct the distribution function at each time step. This allows to tremendously reduce the computational cost of the method and it permits for the first time, to the author's knowledge, to compute solutions of full six dimensional kinetic equations on a single processor laptop machine. Numerical examples, up to the full three dimensional case, are presented which validate the method and assess its efficiency in 1D, 2D and 3D.

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