The Interaction of an Infinite Number of Eddy Flows

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The Boltzmann kinetic equation plays an important role in the kinetic theory of gases. In paper [2], we consider this equation for a model of hard spheres that describes particles of any gas which move translationally with a certain linear velocity, collide by the laws of classical mechanics and can not rotate. For this model, the equation has the form [1]

$$D(f) = Q(f, f), \tag{1}$$

$$D(f) \equiv \frac{\partial f}{\partial t} + \left(V, \frac{\partial f}{\partial x}\right), \tag{2}$$

$$Q(f, f) \equiv \frac{d^2}{2} \int_{R^3} dV_1 \int_{\Sigma} d\alpha |(V - V_1, \alpha)|$$
$$\times \Big[f(t, x, V_1') f(t, x, V') - f(t, x, V) f(t, x, V_1) \Big], \tag{3}$$

and V, V_1, V', V_1' are the velocities of particles before and after collision, respectively, determined by the relations

$$V' = V - \alpha(V - V_1, \alpha),$$
$$V_1' = V_1 + \alpha(V - V_1, \alpha).$$

The solution to this equation will be look for in the next form

$$f(t, x, V) = \sum_{i=1}^{\infty} \varphi_i(t, x) M_i(t, x, V). \tag{4}$$

where $M_i(t, x, V)$ are the exact solutions of the equation (1)-(3)

$$D(M_i) = Q(M_i, M_i) = 0$$

and the coefficient functions $\varphi_i(t, x)$ are nonnegative smooth functions on $\mathbb{R}^4$ and $\varphi_i(t, x) \not\equiv 0$.

As a value of the deviation between the parts of equation (1) we will consider a uniform-integral error of the form

$$\Delta = \Delta(\beta_i) = \sup_{(t,x)\in\mathbb{R}^4} \int_{\mathbb{R}^3} \big| D(f) - Q(f, f) \big| dV. \tag{5}$$

In the paper [2], several cases of coefficient functions $\varphi_i(t, x)$ were obtained for which the deviation (5) can be done arbitrarily small. This is possible thanks to a special selection of hydrodynamic flow parameters.

References

[1] C. Cercignani. Theory and Application of the Boltzmann Equation. *Scottish Academic Press*, Edinburgh, 1975.

[2] O.O. Hukalov, V.D. Gordevskyy. The Interaction of an Infinite Number of Eddy Flows for the Hard Spheres Model. *Journal of Mathematical Physics, Analysis, Geometry*, 2: 163–174, 2021.