Simulations of viscous flows with the Godunov-like SPH method

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The smoothed particle hydrodynamics (SPH), with the Riemann problem solution on interparticle contacts [1] is widely used to model compressible flows with discontinuities. This approach does not require artificial viscosity to stabilize a solution in the vicinity of the discontinuity: stable and monotonous solutions are provided due to the significant viscosity of the numerical Godunov-like scheme itself. The latter linearly depends on particle size and can exceed the physical viscosity of real fluids by several orders of magnitude, which distorts simulations too much.

To overcome the problem we developed numerical viscosity correction method [2]. Previously, numerical viscosity of the contact SPH method was estimated by comparing the simulated and theoretical velocity profiles in the shear flow test. However, the latter had two-dimensional setup which does not allow us to argue that numerical viscosity estimation in three dimensions will be consistent. In this study, based on results of falling ball experiment modelling, we show that numerical viscosity measured with the Stokes method is independent from the flow geometry and is consistent with two-dimensional case.

The developed method for the numerical viscosity correction can be used in engineering applications, which is demonstrated by calculations of the viscous fluid flow around a periodic structure of circular cylinders. Drag coefficients obtained with such method are in good agreement with theoretical ones.

[1] Parshikov A N and Medin S A 2002 *J. Comp. Phys.* **180** 358

[2] Parshikov A N, Rublev G D, Medin S A and Dyachkov S A 2022 *Proceedings of the* 16^{th} *SPHERIC International Workshop* **16** 186 – 191