The Basset history force in point-particle simulations: Optimizing the method of van Hinsberg et al.

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ABSTRACT

The movement of an isolated, small, spherical particle in a Newtonian fluid is governed by the equation presented by Maxey and Riley [1]. This equation is widely used in the numerical simulation of dispersed, particle-laden flows. However, the inclusion of one of its terms, the Basset history force, is especially problematic in practice due to the necessity of calculating, at every time step, a convolution involving the complete past history of motion of the particle, making the computations expensive. Unfortunately, the Basset history term should not be neglected in general, as has been shown by theory [2] and numerics [3].

In this respect, the method proposed by van Hinsberg et al. [4] represented a significant step forward, circumventing the necessity of keeping track of the full history of motion, while still maintaining accuracy under control. The method is based on the approximation of the Basset convolution kernel by a sum of exponentials bearing unknown parametric coefficients. These coefficients are to be determined by combining heuristic arguments with an optimization problem.

In this work we examine the method in detail, analyzing its performance in a series of numerical tests of increasing complexity. We furthermore generalize the optimization problem to avoid the heuristics in fixing the parameters. As a result, we obtain optimal parametric coefficients, ready to use in practical cases. We show that the method is accurate and yields adequate computation times for real-life simulations. Finally, we comment on current work regarding additional directions in which the method can be improved.

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