Fundamental Study of Moving Particle eXpricit (MPX) Method

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ABSTRACT

The strong form particle methods such as the Smoothed Particle Hydrodynamics (SPH) [1] method and the Moving Particle Semi-implicit (MPS)[2] method have been shown to be useful widely in engineering applications especially in computational fluid dynamics. The early SPH method [1] with fully explicit algorithm was originally applied for compressible and weakly compressible flows, and the beginning MPS method [2] with semi-implicit algorithm was intrinsically developed for incompressible flows, respectively.

Recently semi-implicit time integration schemes have been utilized in the SPH methods [3,4] for incompressible flow analyses – vice versa, explicit procedures have been adopted in the MPS methods [5] for weakly compressible medium. Naturally, both of time integration schemes have advantages and disadvantages. For instance, fully explicit discretization technique provides a fast computation of which parallelization is much easier than semi-implicit one; however, it is less accurate and stable, and smaller time-stepping related with the well-known CFL-condition for pressure waves is required. On the other hand, solving large-dimension sparse linear system in the semi-implicit algorithm results in high computational cost; however, relatively stable and accurate solution would be obtained, and larger time stepping can be utilized. It is difficult to say which is better, and one must put the right man in the right place.

In this study, Moving Particle eXplicit (MPX) method is developed. MPX fundamental discretization procedures are based on the Least Squares Moving Particle Semi-implicit (LSMPS) method [6], since its formulations are consistent, and the pressure-velocity splitting solvers are changed from implicit algorithm to explicit one. Utilizing a relaxation technique of incompressible constraint with cycle-to-cycle self-adjustment of mass conservation contributes this alteration. Since a novel algorithm is explicit, a parallel computing of the MPX algorithm is easier to implement than the LSMPS one, which requires parallelization of the algebraic multi-grid (AMG) preconditioned iterative solver. The present MPX method could be a solution for the problem such that: (I) a huge number of particles are required to discretize a spatial domain, (II) a massively parallel computing is utilized, and (III) a rigorous incompressibility condition is not so important for the flow solution.

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