Compatible high-order meshless discretization via moving least squares

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Abstract

Meshless methods promise an effective means of discretizing Lagrangian hydrodynamics and interfacial flows by avoiding the computational expense of maintaining high quality deforming meshes at each timestep. By abandoning a mesh however, we lose the exterior calculus framework that forms the foundation for traditional mesh-based compatible discretizations. In this work, we present new discretization generalizing classical staggered discretization on primal/dual meshes to an epsilon-ball graph constructed from particle locations. This meshless discretization enjoys high-order convergence and stability properties typical of compatible mesh-based methods. For the div-grad and curl-curl model problems, equal order L2 and H1 convergence is obtained for smooth solutions, while nearly-monotone fluxes are maintained for the discontinuous case. For the steady Stokes problem, equal-order convergence is obtained for both pressure and velocity. For both of these problems, a sparse discretization is obtained that can be efficiently preconditioned using standard AMG techniques. In this talk we present fundamental approximation properties of these schemes along with results that use this approach as a foundation to develop monolithic solvers to study problems in dense suspension flows driven by electrokinetic effects.