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Direct modeling of dense particle suspensions using high order time-integration schemes

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Modeling particle suspensions in incompressible fluids is of interest in fields ranging from crystal rich magmatic intrusions to flow of proppant packings. This is a particularly challenging task when modeling the regime of large volume fractions, which is dominated by particle interactions. A high order of accuracy in the spatial discretization, e.g., high order finite element methods, is not sufficient alone to ensure the resolution of particle dynamics. An artificial repulsive force between the particles is often introduced in numerical schemes to prevent the development of spurious particle overlaps. Here, we study in detail the time integration of particle trajectories using various high order time-integration schemes. In addition, an adaptive unstructured finite element formulation of two-dimensional particle-laden flows is combined with the Richardson extrapolation technique to obtain highly accurate particle velocities.