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DMSwarm: Particles in PETSc

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Whilst specific details of particle methods are as diverse as the applications in which they are utilized within, such methods have a number of common requirements. Specifically these entail: the need to attach data (or fields) to each point; support for the advection of points within some domain; dynamic insertion and deletion of points; collection type operations to gather nearby points; and methods to interpolate and restrict data back and forth between a set of points and a background mesh. Despite the commonality of these requirements, to date, few computational libraries provide high level support for particle methods in either a sequential, or parallel (MPI) computing environment.

In this presentation, we describe the recently introduced implementation DMSwarm within the Portable, Extensible Toolkit for Scientific computing (PETSc) which provides a fully parallel solution for pure particle methods (e.g. DEM, SPH, EFG) and for particle-mesh methods (e.g. PIC, FLIP, MPM, GIMP).

Particle-In-Cell (PIC) methods with geodynamic simulation tools are ubiquitous. To illustrate the functionality provided by DMSwarm, we present results from viscous flow calculations using a finite element PIC method applied to study Rayleigh-Taylor instabilities using both structured and unstructured meshes. Our results are derived from standard examples provided with the PETSc source distribution and serve as an entry-point for new users to learn how to incorporate DMSwarm into their geodynamic software.