数学与系统科学研究院

计算数学所学术报告

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报告题目：

Towards a Highly Scalable Incompressible Smoothed Particle Hydrodynamics (ISPH) toolkit: Optimization for real applications

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上午 **10:00~11:00**

报告地点： 数学院南楼七层

702 会议室

Abstract:

The major challenges caused by the increasing scale and complexity of the current petascale and the future exascale systems is imposing a strong evolutionary pressure on numerical algorithms and software ecosystem.

Smoothed Particle Hydrodynamics(SPH) codes have been effectively parallelised using domain decomposition methods, implemented with libraries such as MPI for a long time. However, How to efficiently maintain geometric locality of particles within processors and deal with dynamic load balancing arising from solving a complex, highly nonlinear and distorted flow is still hot topic.

Constructing neighbour list and solving pressure Poisson equation are two critical points in terms of the high performance of the Incompressible SPH codes. The parallel efficiency of the SPH software applications requires effectively mininizing communications between processors and good load balancing.

Base on the above motivations, this paper describes an alternative partitioning and dynamic load balancing approach by using Hilbert space filling curve to decompose the cells with number of particles in each cell as the cells' weight functions. This approach can distribute particles evenly to MPI partitions, and in the mean time, without losing spatial locality which is critical for neighbour list searching. As a trade-off, the subdomain shape become irregular. The unstructured communication mechanism has also been introduced to deal with halo exchange. Solving sparse linear equations for pressure Poisson equation is one of the most time consuming parts in ISPH, ISPH uses multigrid preconditioners and solvers from PETSc. The particles has been reorded so that insertions of values to global matrix become local operations without incurring extra communications, which also have a benefit of reducing the bandwidth of coefficients matrix. We have demonstrated that domain decomposition with space filling curve can efficiently deal with irregular distributed particles. The method can are perfectly match the nature of non-uniform spatial distribution of SPH particles during simulations, which also offers capability of developing parallel adaptive SPH within an ISPH toolkit. The performance analysis and results show the promising efficiency with very large number of cores.

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