Optimizing Gyrokinetic Particle Codes for Extreme Scale Computing

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Gyrokinetic particle-in-cell codes have been very successful at keeping up with the fast-evolving technology of high performance computing. The high level of parallelism contained in the particles allows the particle-intensive parts of the PIC codes to easily scale to a very large number of processors. However, the grid-intensive parts of the calculation, such as the field solve and field smoothing, are a lot harder to scale. They contain little parallelism compared to the particles and require domain decomposition to be efficiently distributed across processes. In addition, the toroidal geometry used by gyrokinetic codes to simulate tokamak fusion devices further complicates the task of performance optimization. This work presents the strategy that we have pursued in recent years to push our gyrokinetic PIC codes to a new level of performance and scalability. Mixed-model MPI+OpenMP as well as multi-dimensional domain decomposition are discussed as well as optimizations specific to multi-core processor.