

Dynamic Adaptive Runtime Systems for Advanced Multipole Methods

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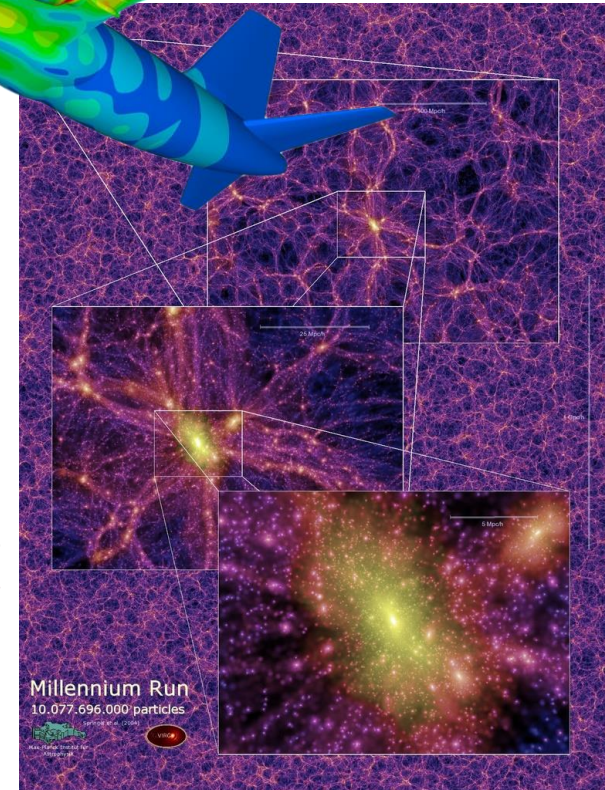
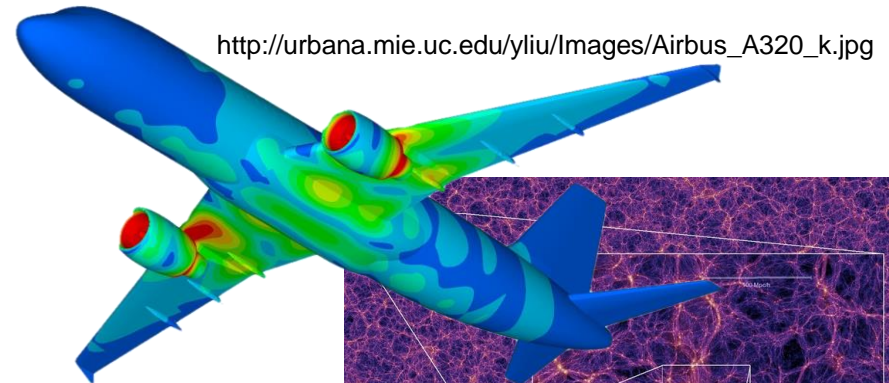
Bo Zhang, Matt Anderson, Thomas Sterling



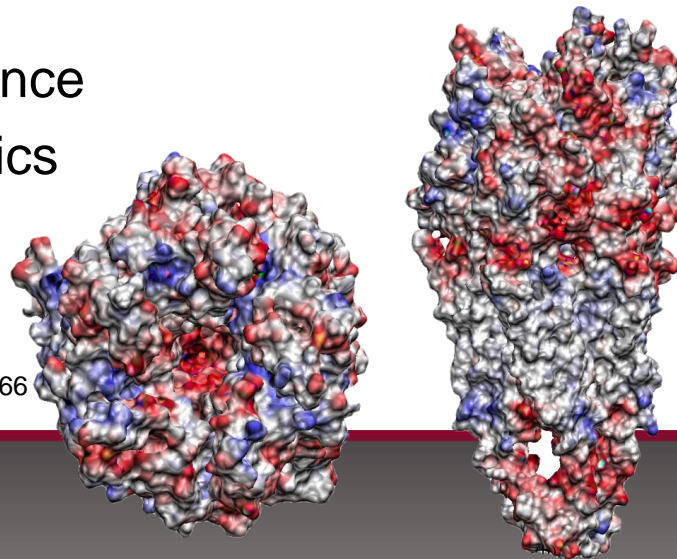
Center for Research in Extreme Scale Technologies

Multipole Methods

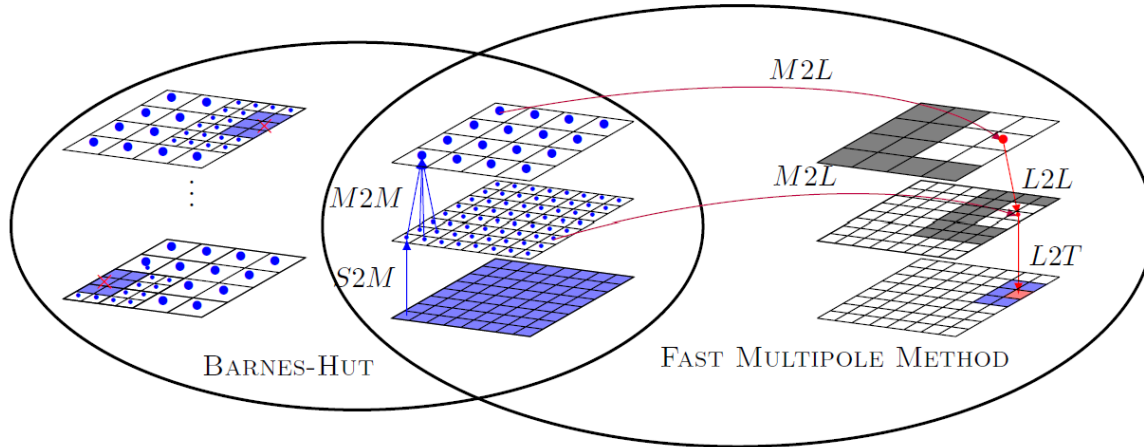
- Key computational kernel for many end-science applications
 - Astrophysics
 - Electromagnetic device design
 - Biology
 - Materials science
 - Fluid mechanics
 - Geophysics



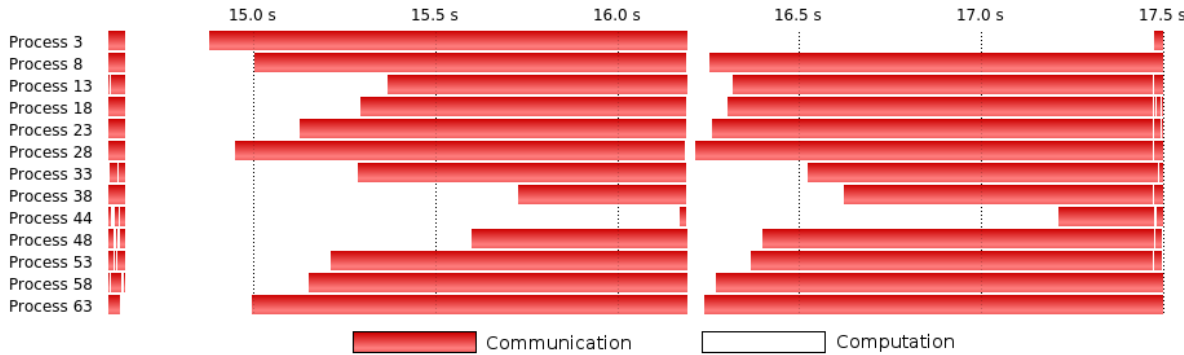
J. Comput. Phys. 226 (2007) 1348--1366



MM Parallelization Challenges



- Dynamic problem, static parallelization methods
- Grain size mismatch
- Starvation
- Low data reuse



GADGET-2 execution trace



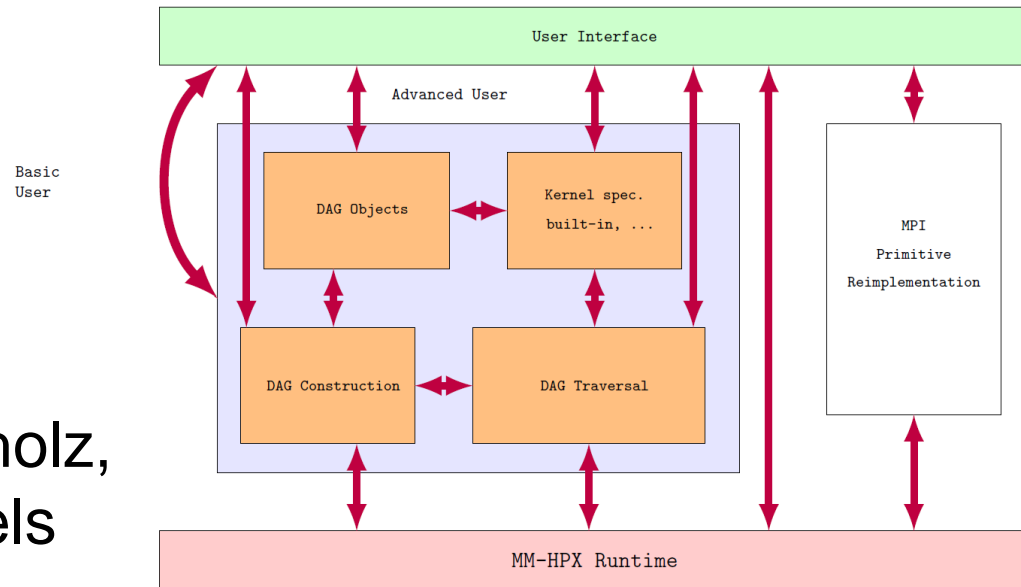
ParalleX and HPX-5

- ParalleX: experimental execution model
- **Starvation**
- **Latency**
- **Overhead**
- **Waiting**
- **Energy efficiency**
- **Resilience**
- HPX-5: implementation of ParalleX
- Lightweight, ephemeral, user-level threads
- Local Control Objects
- Parcels
- Active Global Address Space

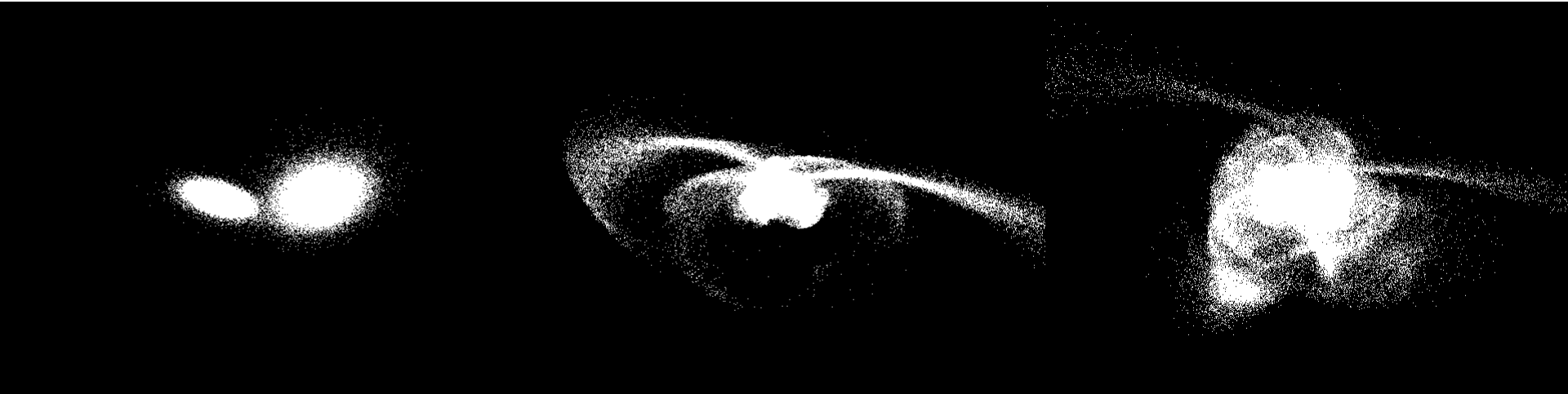


Dynamic Adaptive System for Hierarchical Multipole Methods

- Use HPX-5 to improve strong scaling and efficiency
- Easy to use
- Rapid integration into existing codes (MPI interoperability)
- Laplace, Yukawa, Helmholtz, and user-specified kernels
- Flexible implementation of FMM and BH



DASHMM: Current Progress



- Great SMP scaling (97.5% parallel efficiency)
- Laplace kernel implemented
- Data-driven adaptive BH and FMM implemented
- Can outperform GADGET in SMP
- <https://www.crest.iu.edu/projects/dashmm/>

