

# SI2-SSE: GEM3D: Open-source Cartesian adaptive complex terrain atmospheric flow solver for GPU clusters

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## Motivation & Objectives

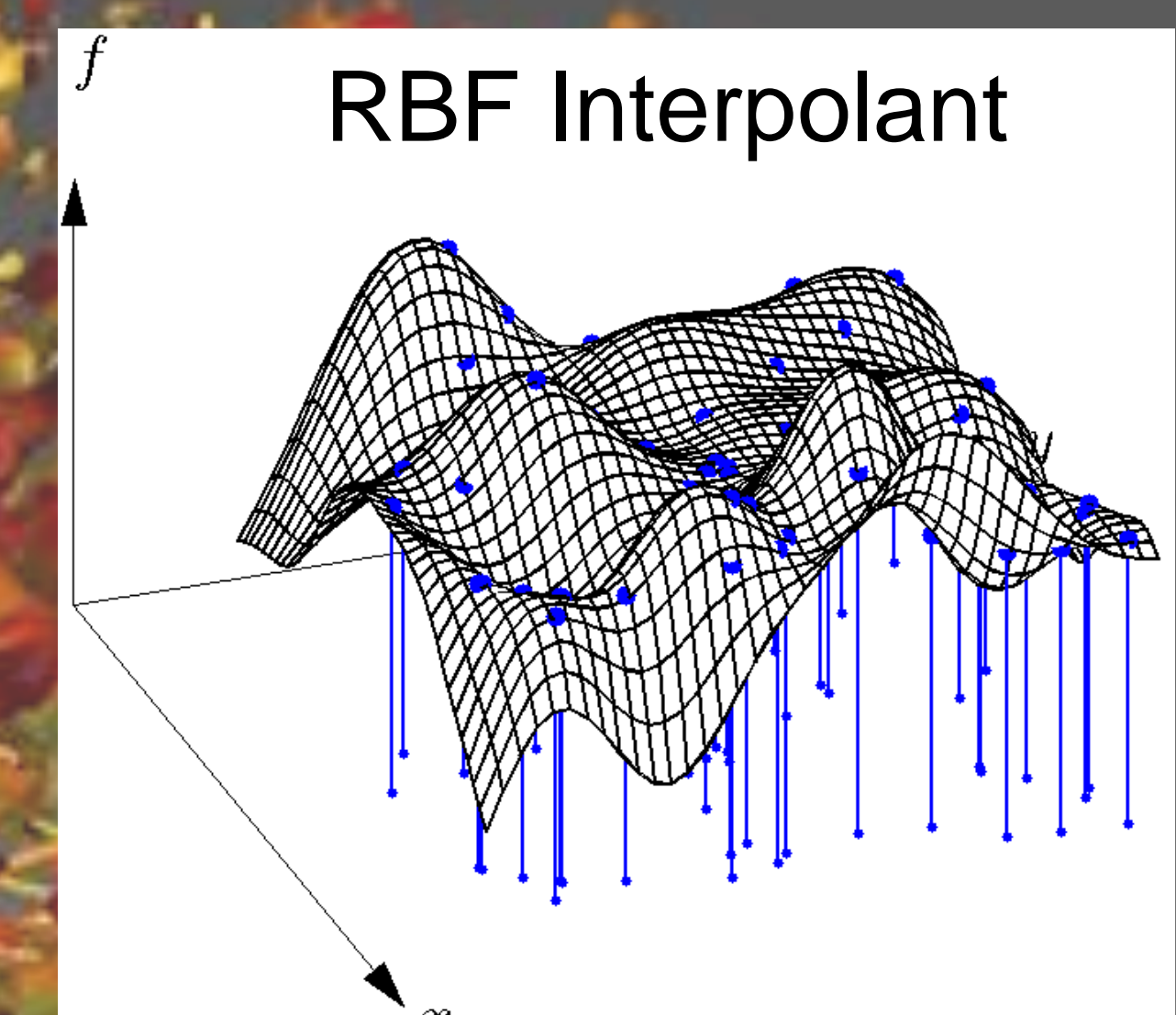
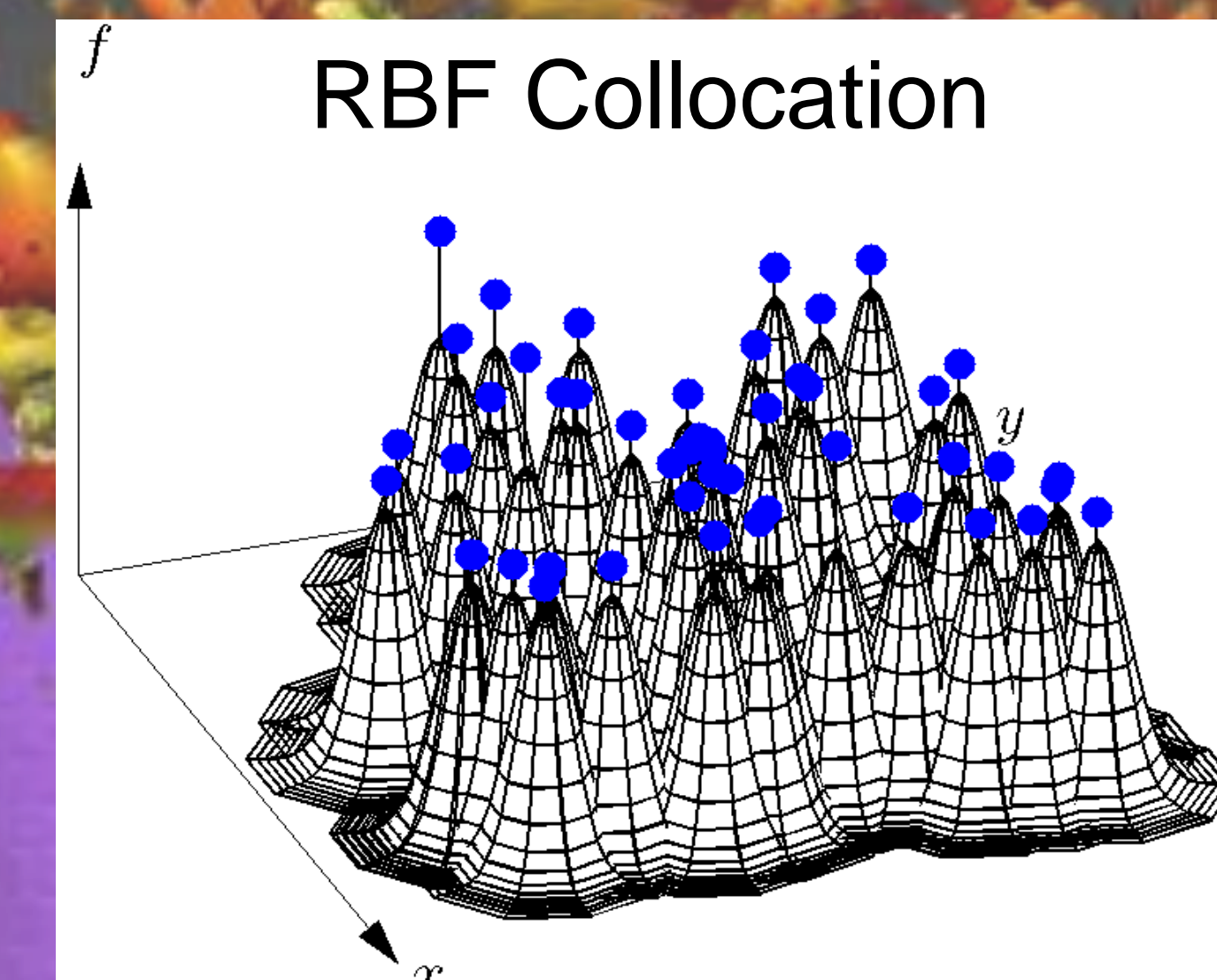
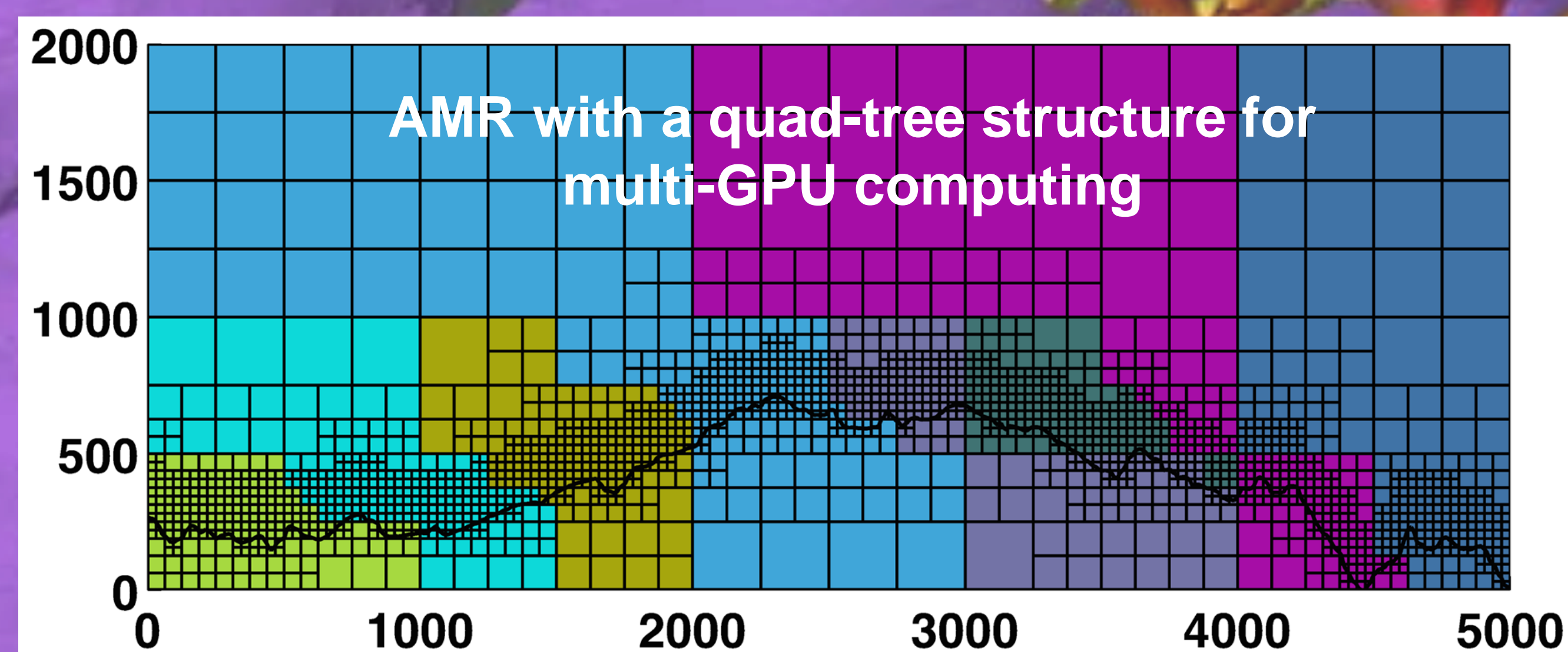
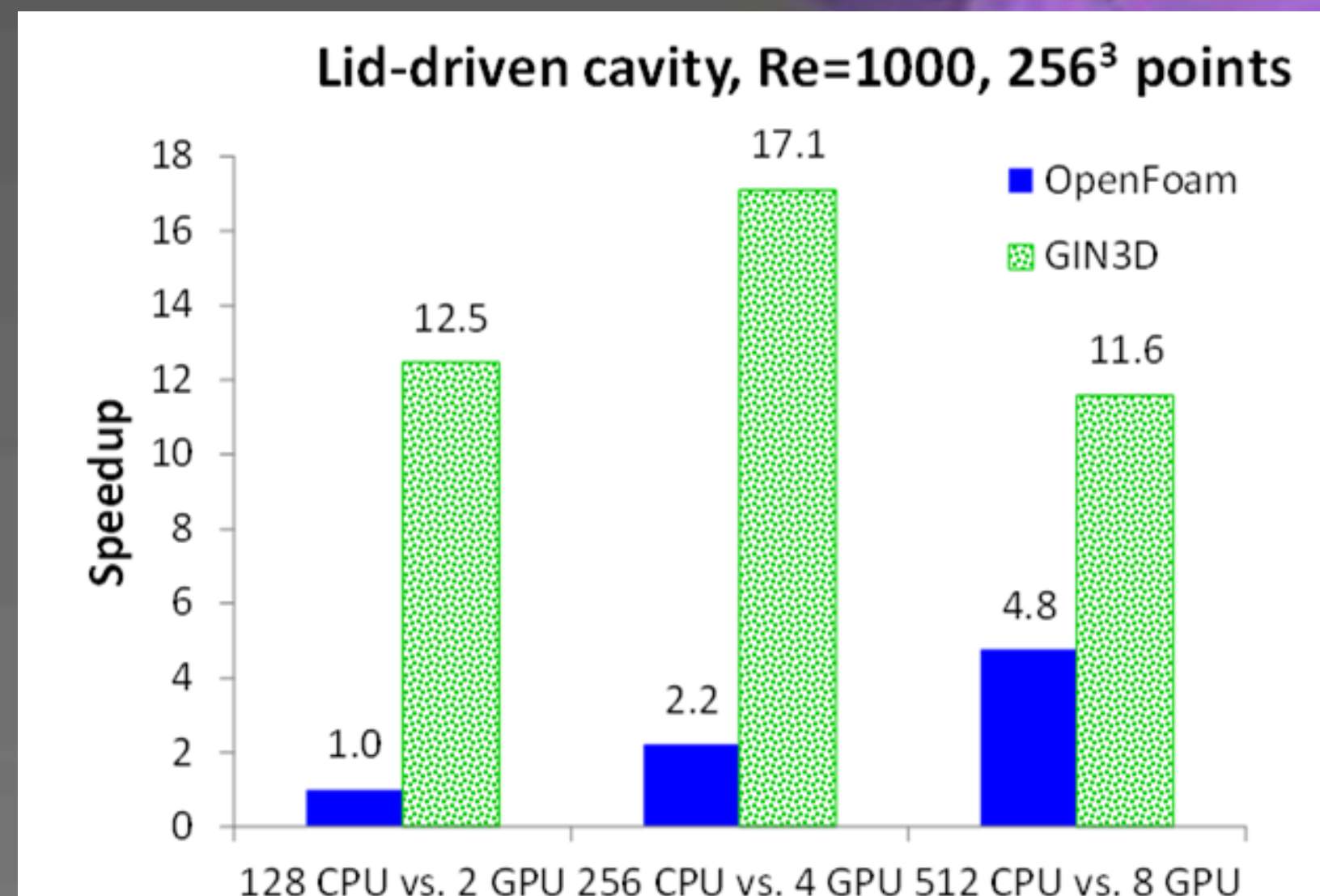
- Increasing availability of many-core computing from the personal laptop to the national supercomputers.
- Develop an open-source massively parallel incompressible flow solver for arbitrarily complex geometry.
- Adhere to software engineering principles
- Target applications in wind resource assessment and forecasting, and chem-bio agent dispersion

## GEM3D

- Open-source community code
- Incompressible formulation
- Projection method
- Multi-GPU parallel multigrid on AMR
- Kinetic-energy conserving scheme
- Runge-Kutta based time marching
- Immersed boundary for complex geometry
- Large-eddy simulation technique for turbulence modeling
- Modern software design

## Multi-GPU Computing

- Dual-level parallelism with MPI-CUDA
- 3D domain decomposition
- Overlapped computation and communication
- Object-oriented design with C++
- Abstraction layer for domain scientists
- Hardware-oriented numerics
- Adopt dynamic parallelism and concurrent kernel execution extensively



## Adaptive Mesh Refinement (AMR)

- AMR library suitable for the grid-block-thread hierarchy of the CUDA programming model
- Embrace CUDA's dynamic parallelism
- Adopt a quad-tree refinement
- Refine the resolution in regions mandated by the underlying physics
- Abstract the numerics on AMR mesh from the domain scientists

## Radial Basis Functions (RBFs)

- Mesh-free by design
- Generalize polynomial based methods to non-tensor product grids
  - e.g. RBF finite differences
- Treat AMR mesh points as scattered data to develop elliptic solvers
- Suitable for complex geometry
- Exploit the flexibility of RBF to improve accuracy at coarse/fine mesh interfaces

## Software Objectives

- Object oriented design principles
  - e.g. SOLID & DRY
- Design for scientific computation in mind
- Maintainable and readable
  - Conform secure coding standards
  - Shallow object hierarchy for coherent code architecture
- MPI-SPIN and GKLEE for software verification