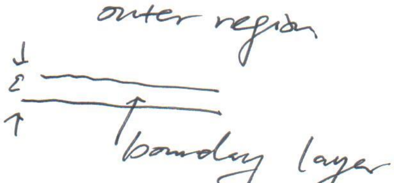
Multiscal Problems.

Multiphysics hierachy

QM → Particle Method / Molecular Mechanics → Kinetic theory / Brownian dynamics → Continuum Model.

Analytical Method.

Matched Asymptotics



Averaging & homogenization methods.

Scaling & renormalization group methods.

Numerical Method.

Resolving the details of the solutions.

linear scaling algorithm.

computational complexity ~ # of dof

accuracy ~ (# of dof)$^{-1}$

MG, FMM, AMR, DD

fast multipole (adaptive mesh refinement) domain decompos

地址：上海市闵行区东川路 800 号上海交通大学包玉刚图书馆 6 楼 邮编：200240
Add：6F, Pao Yue-Kong Library,No. 800 Dong Chuan Rd. Shanghai 200240,P.R.China
Web：http://zhiyuan.sjtu.edu.cn/ E-mail：zhiyuan@sjtu.edu.cn
Tel：86-21-54745845 Fax：86-21-54747161

Sublinear scaling Algorithm

Computational complexity << # of dof of the fine scale Problem.

aim: 1. resolve certain features of the microscale soln
e.g. average behavior

2. microscale solution has some particular features to take advantage of
e.g. homogenized soln (scale separation)
defects.
orbitals. etc.

Two types of Multiscal Problems.

A: Problems the microscale model is needed everywhere.
~~bone~~ hope to find a macroscopic model or reduced dimension approximation → numerical homogeniz

B: Problems with local singularities or defects
dislocation, shock, boundary layer.
→ coupling

地址：上海市闵行区东川路 800 号上海交通大学包玉刚图书馆 6 楼 邮编：200240
Add：6F, Pao Yue-Kong Library,No. 800 Dong Chuan Rd. Shanghai 200240,P.R.China
Web：http://zhiyuan.sjtu.edu.cn/ E-mail：zhiyuan@sjtu.edu.cn
Tel：86-21-54745845 Fax：86-21-54747161

Concurrent vs. Sequential Coupling.

Sequential Coupling: Macroscopic Model determined first,
(Serial) except for some parameters, which can be computed or tabulated by a microscopic model.

Pre-computing information (if fens of a few variables)
microscopically-informed modeling.
parameter-passing.

Concurrent Coupling:

Obtain the information 'on the fly'
Suitable if the unknown parameters depends on many variables.

地址：上海市闵行区东川路 800 号上海交通大学包玉刚图书馆 6 楼 邮编：200240
Add : 6F, Pao Yue-Kong Library,No. 800 Dong Chuan Rd. Shanghai 200240,P.R.China
Web : http://zhiyuan.sjtu.edu.cn/ E-mail : zhiyuan@sjtu.edu.cn
Tel : 86-21-54745845 Fax : 86-21-54747161

致远学院
ZHIYUAN COLLEGE
上海交通大学基础学科拔尖学生培养试验计划

Main Challenges.:

1. Basic understanding of the physical models at different boundary condition. scales ...

2. Understanding how models of different complexity are related to each other

Limit?

3. Understanding how models of different complexity can be coupled together without creating artifacts.

A/C

4. Understanding how to formulate models at intermediate levels of complexity or 'mesoscale' models

atomistic → Ginzburg-Landau → hydrodynamic.
Phase field model.

地址：上海市闵行区东川路 800 号上海交通大学包玉刚图书馆 6 楼 邮编：200240
Add : 6F, Pao Yue-Kong Library,No. 800 Dong Chuan Rd. Shanghai 200240,P.R.China
Web : http://zhiyuan.sjtu.edu.cn/ E-mail : zhiyuan@sjtu.edu.cn
Tel : 86-21-54745845 Fax : 86-21-54747161

Examples:

1. Coarse Graining — $-\nabla a \nabla u = f$, $a \in L^\infty$ — error $\| \ \| \sim \frac{1}{N}$ → coarse dof
   — granular materials

2. A/C coupling — ghost force. error $\| \ \| \sim \frac{1}{N}$ → Coarse dof.

3. Tensor Approximation

   SVD.

   Multiscale decomposition.

   Tensor approximation for high dimensional problems.

地址：上海市闵行区东川路 800 号上海交通大学包玉刚图书馆 6 楼 邮编：200240
Add : 6F, Pao Yue-Kong Library,No. 800 Dong Chuan Rd. Shanghai 200240,P.R.China
Web : http://zhiyuan.sjtu.edu.cn/ E-mail : zhiyuan@sjtu.edu.cn
Tel : 86-21-54745845 Fax : 86-21-54747161