Last Class

A segue into simulations

Throwing everything into the mix

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Is simply not feasible

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Remember Tom's presentation?

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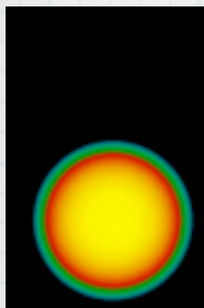

Throwing everything into the mix

Is simply not feasible

Remember Tom's presentation?

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* 16 cores running 7 days

Throwing everything into the mix

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Remember Tom's presentation?

* 16 cores running 7 days
* with 3 million grid points

Throwing everything into the mix

Is simply not feasible

Remember Tom's presentation?

* 16 cores running 7 days
* with 3 million grid points
* 225,000 time steps

Throwing everything into the mix

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Remember Tom's presentation?

* 16 cores running 7 days
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* Solving 9 equation for 8 variables

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* Solving 9 equation for 8 variables
* Each variable is 8 bytes so 64 bytes per point for 3 million grid points or about 30 megabytes of data per dump

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* Each variable is 8 bytes so 64 bytes per point for 3 million grid points or about 30 megabytes of data per dump
* and this is a toy model
* In three dimensions this would be 320 times bigger and longer for this problem

So what do you do?

* You use a computer
* In reality you use several linked computers so you can run on 2,4,98,16,32,....512,1024,2048,etc cores at once
* Right now you can throw as many computers at a problem as you want
* The limitations are in how fast different computers can transfer data between them

So what do you do?

* Presently the Infniband network is the fastest with a top speed of 300 gigabits/s or about 40 gigabytes per second
* Seems fast until you recall the data needed for a 3d version of Tom's project
* This is the present roadblock in super computing

So what do you do?

* What you do is determine the problem to solve
* Find the system of equations used to solve them
* Find a tractable analytic method to turn differential equation to algebraic equations
* Initialize a grid initial conditions
* Subdivide this grid so each core gets a chunk of it
* Solve the system on multiple cores

So what do you do?

* Must pass boundary conditions between cored (the network comes into play here)
* Dump data at pre determined intervals
* If we dumped all of Tom's data it would be 6 million megabytes or 6000 gigabytes or 6 terabytes of data or 3000 regular hard drives of data, for a 3D run it would be about 18 petabytes or about 1 million harddrives

So what do you do?

* Seems fancy?
* Not going to happen, must be picky in what data to keep
* Today we can reach speeds of 10s of petaflops or 10^{16} floating point operations per second
* The power is getting better
* The bandwidth and storage (and power consumption) is still an issue
* And the power isn't even enough for many problems

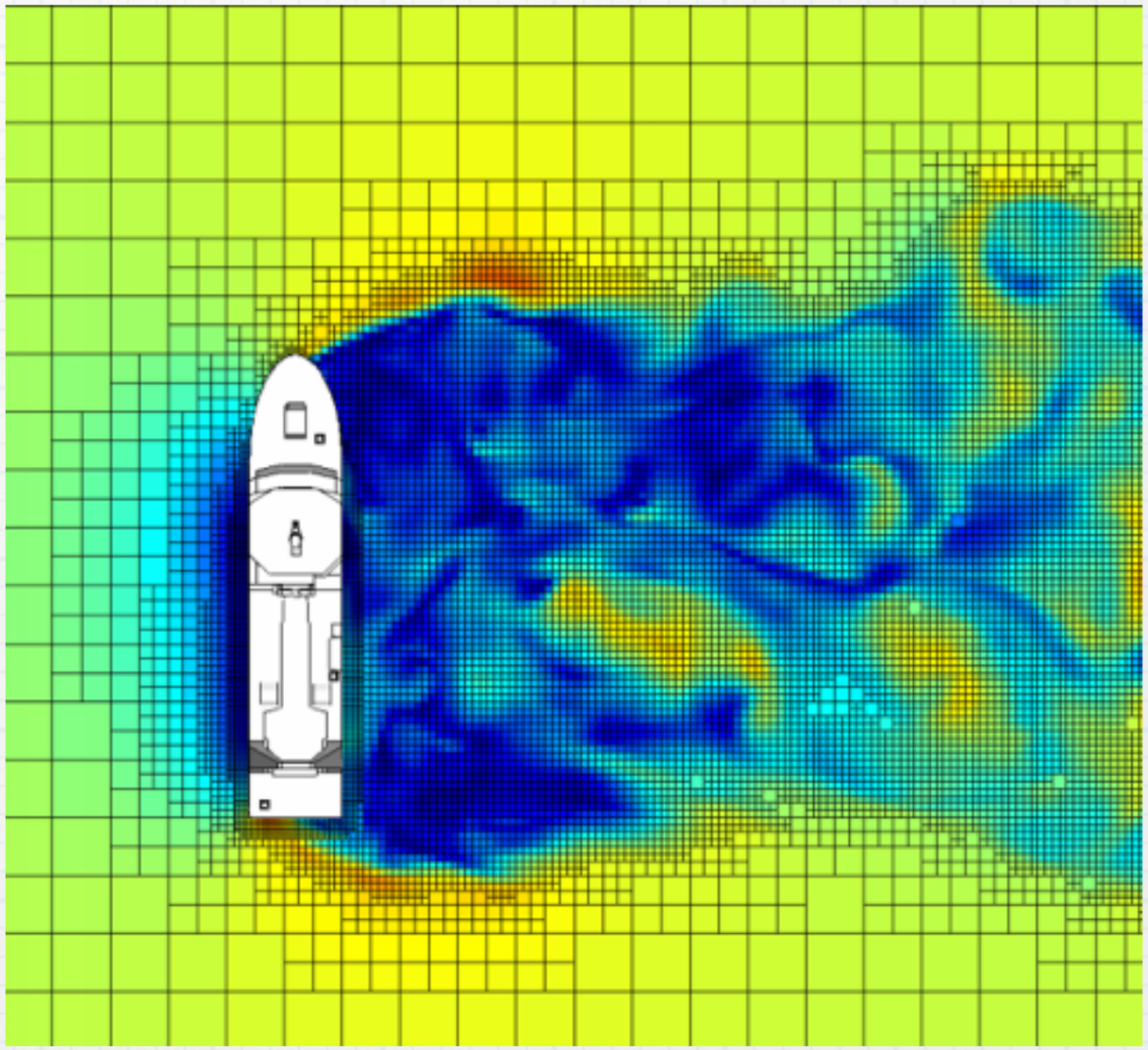
In astrophysics

* Data is taken from distant objects, we need engineers to build the machines
* Observers set the observational data and reduce it
* Theorists then try to say from as close to first principle what is happening with the object

* We can't do experiments in astrophysics so we rely on modeling to try to understand what's happening
* Look at a star, use the stuff from this course to build a model, use a computer to solve the model using coupled PDEs then see if your model reproduces observations
* If yes you have supported your model and refine it to do better
* If no, try again

Examples from astrophysics

* Type Ia supernovae
* GRBs
* Use a fluid solver
* Example Flash Code
* SMR
* SR
* MHD
* Nuclear burning chains



Flash Code

* http://flash.uchicago.edu/site/movies/
* http://grb.physics.ncsu.edu/grbmovies.html#3Dsch

Cosmological simulations

* SPH
* Millennium Simulation
* http://www.youtube.com/watch?v=yyfpFfWq7Bc
* Bolshoi Simulation
* http://hipacc.ucsc.edu/Bolshoi/

Colliding Galaxies

* http://www.youtube.com/watch?v=_FlGiqPdbx8

More

* type 2 sn http://www.youtube.com/watch?v=jgv6lJnRrll
* GRMHD
* http://www.youtube.com/watch?v=71_1_otAhwA
* http://www.youtube.com/watch?v=GtpMyte4a4A

More

* Stellar dynamos
* http://vimeo.com/26409236

This doesn't stop with astrophysics

* http://www.youtube.com/watch?v=4ag_jxWnoz0
* http://www.youtube.com/watch?v=VKoZCzlBoDk
* http://www.youtube.com/watch?v=wq12nlQ5SuE

Real Physics

* Requires computers
* It's been a fun semester, sorry about the radiative transfer part