MIF Generator for OOMMF

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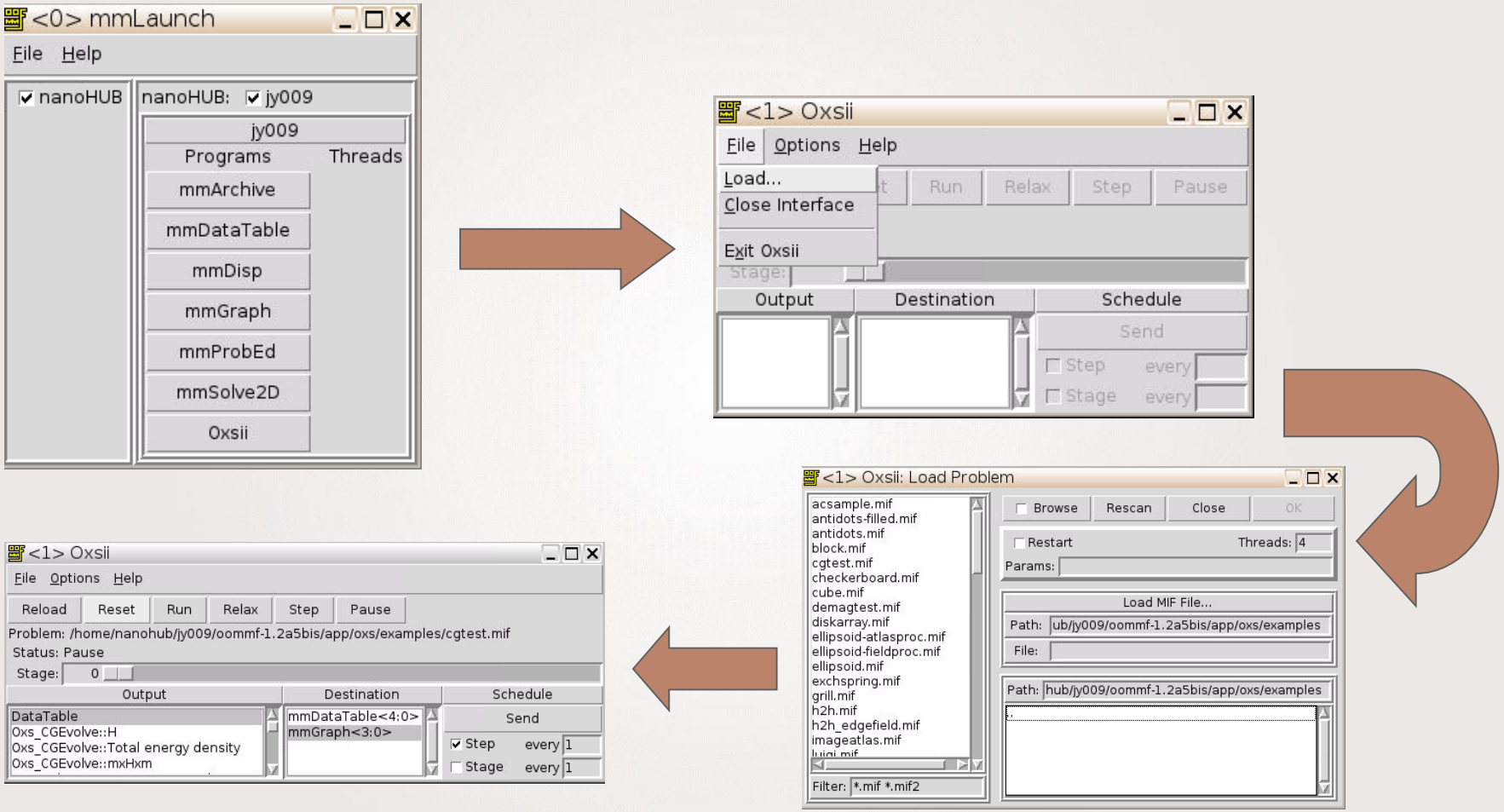
Oxsii

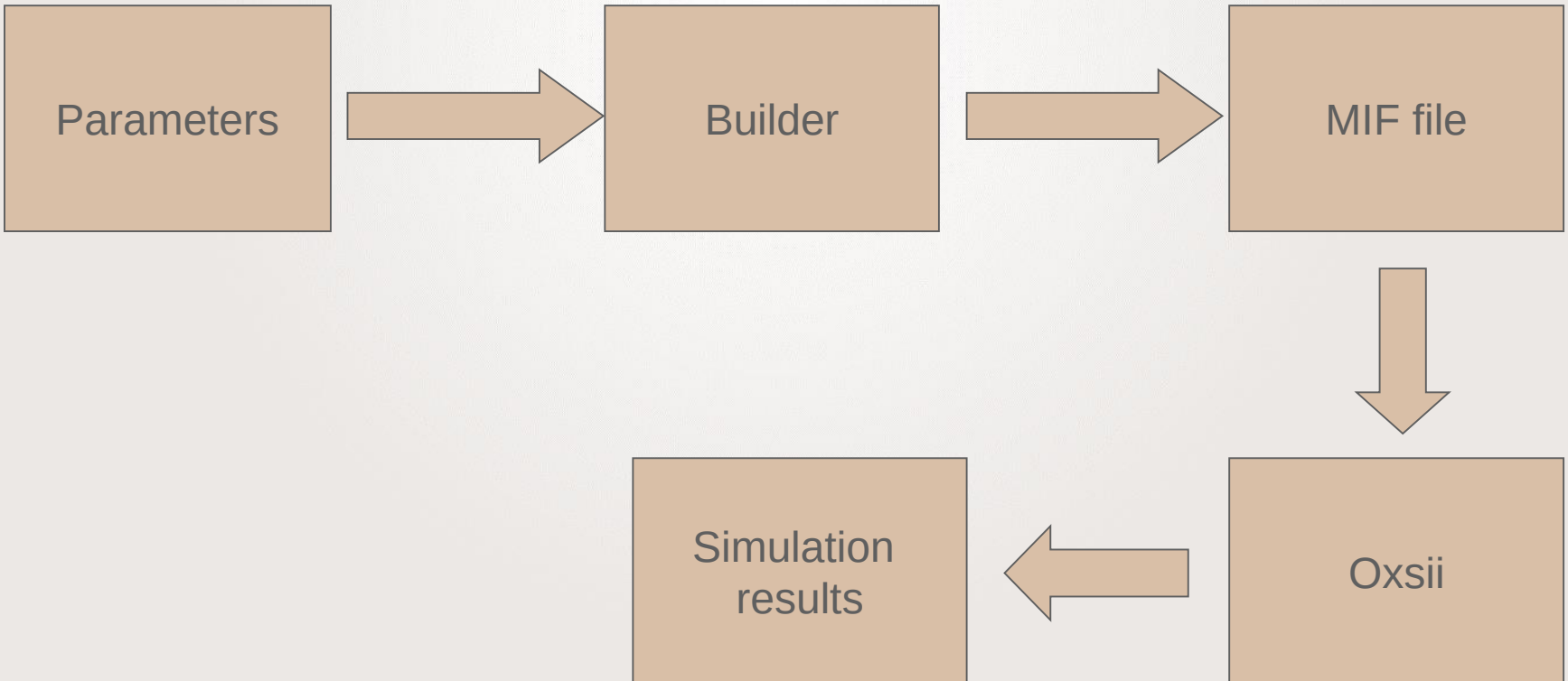

<0> mmLaunch
File Help
nanoHUB
nanoHUB: jy009
jy009
Programs
Threads
mmArchive
mmDataTable
mmDisp
mmGraph
mmProbEd
mmSolve2D
Oxsii
<1> Oxsii
File Options Help
Load...
Close Interface
Exit Oxsii
Run
Relax
Step
Pause
Stage:
Output
Destination
Schedule
Send
Step every
Stage every
<1> Oxsii: Load Problem
acsample.mif
antidots-filled.mif
antidots.mif
block.mif
cgtest.mif
checkerboard.mif
cube.mif
demagtest.mif
diskarray.mif
ellipsoid-atlasproc.mif
ellipsoid-fieldproc.mif
ellipsoid.mif
exchspring.mif
grill.mif
h2h.mif
h2h_edgefield.mif
imageatlas.mif
Browse
Rescan
Close
OK
Restart
Threads: 4
Params:
Load MIF File...
Path: ub/jy009/oommf-1.2a5bis/app/oxs/examples
File:
Path: hub/jy009/oommf-1.2a5bis/app/oxs/examples
Filter: *.mif *.mif2
<1> Oxsii
File Options Help
Reload
Reset
Run
Relax
Step
Pause
Problem: /home/nanohub/jy009/oommf-1.2a5bis/app/oxs/examples/cgtest.mif
Status: Pause
Stage: 0
Output
Destination
Schedule
DataTable
Oxs_CGEvolve::H
Oxs_CGEvolve::Total energy density
Oxs_CGEvolve::mxHxm
mmDataTable<4:0>
mmGraph<3:0>
Send
Step every 1
Stage every 1

Difficulties - MIF

- Provided examples are limited
- not user friendly
  - MIF programming is hard
  - User-guideline (Child-class functions)

Implementation - model builder

- Generate customized model without knowing MIF programming and complete understanding of the user guidelines.
- Use rappture to create a Graphical User Interface.



Parameters

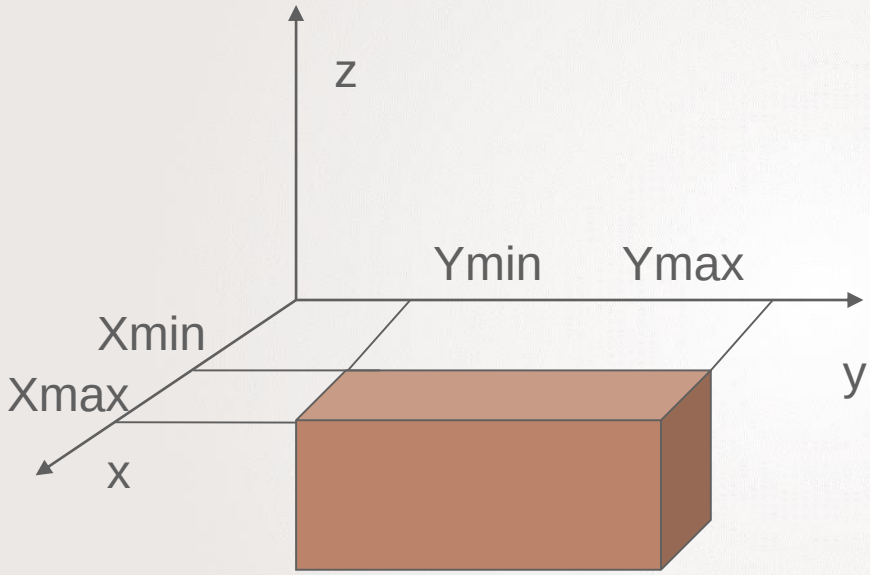
- Dimensions of the model
- Mesh
- Energy functions
- Evolver functions
- Driver functions

Dimension

- Geometric volumes of spaces
- cube (a,b,c)
- multiple cubes
- ellipsoid

cube

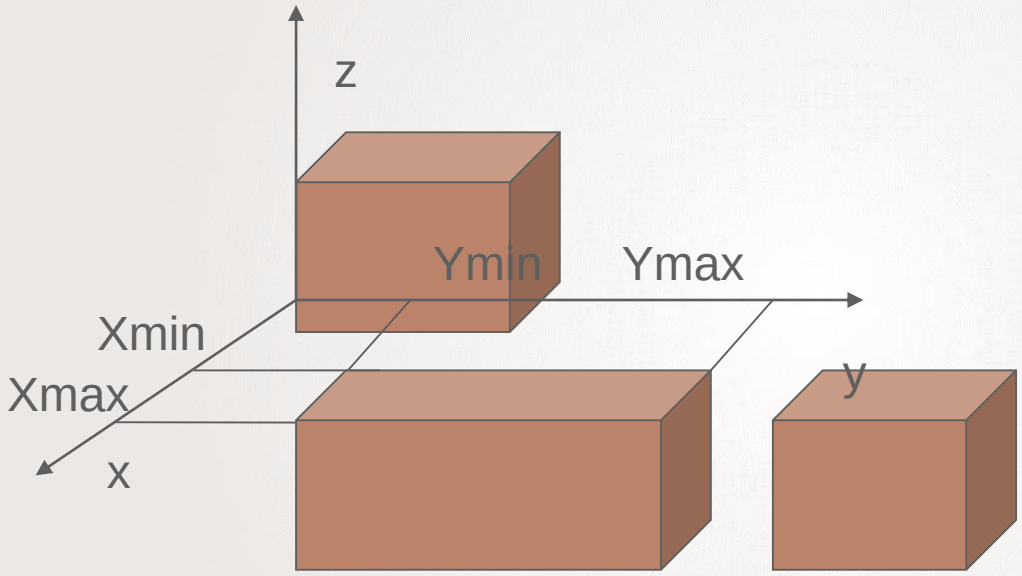
- 6 numbers



- Projections of the cube along x, y ,z direction.

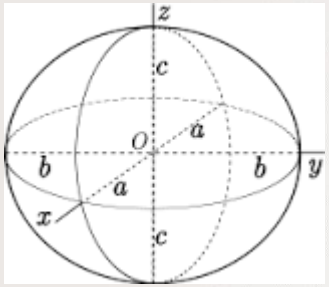
multiple cubes

- Different shape, need not be disjoint, can up to



Ellipsoid

- define radii (a, b, c)



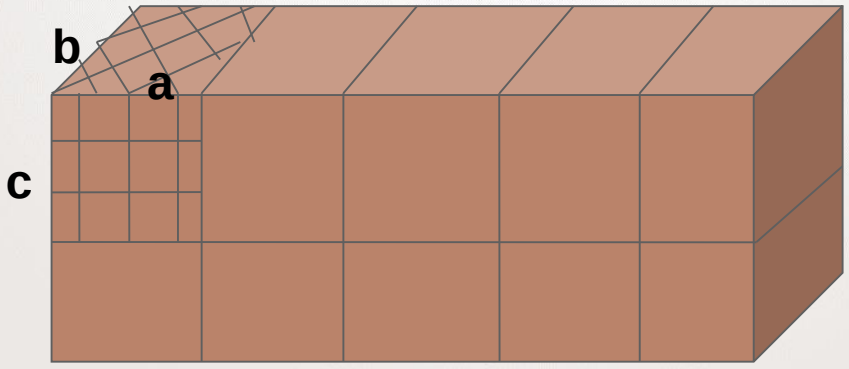
https://en.wikipedia.org/wiki/Ellipsoid#/media/File:Ellipsoid_tri-axial_abc.svg

And more highly customized...

- not built in function
- can be designed within the tool
- arrays, cylinders, etc

Mesh

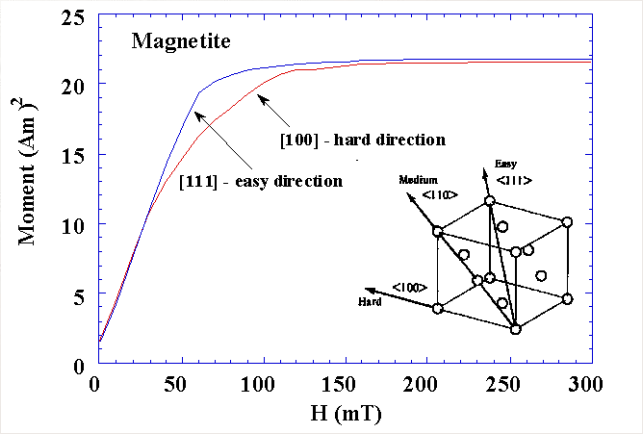
- define the discretization impressed on the simulation.
- creates an axes parallel rectangular mesh across the entire space.
- cell-based, with the center of the first cell one half step in from the minimal extremal point.



Anisotropy Energy

- In physics, a ferromagnetic material is said to have magnetocrystalline anisotropy if it takes more energy to magnetize it in certain directions than in others.
- 'Easy axis' = takes no energy to magnetize along that direction.
- Uniaxial Anisotropy has one easy axis.
- Cubic Anisotropy has two easy axis.
- Inputs: **easy axis** and **anisotropy constant**.

$$E = KV\left(1-\gamma^2\right) = KV\sin^2\theta,$$



Exchange Energy

- Exchange interaction is a quantum mechanical effect between identical particles.
- a wavefunction which describes the pair must be antisymmetric with respect to exchange of the electrons
- the difference in energy between aligned and anti-aligned configurations is what is called the exchange energy

Exchange Energy

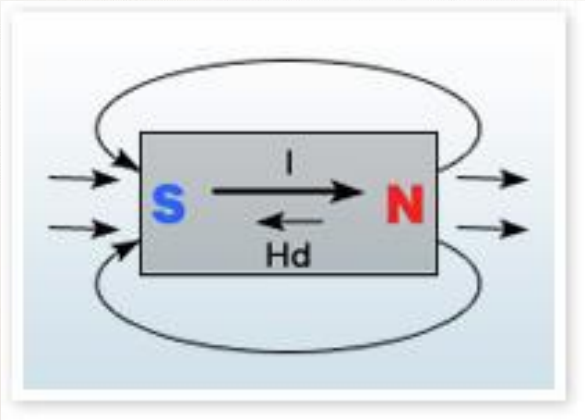
- Input: Exchange Constant

$$J_{ab} = \frac{1}{2}(E_+ - E_-) = \frac{J_{ex} - CB^2}{1 - B^4}$$

- C:Columbus integral, B:overlap integral, Jex:exchange integral, Jab: exchange constant, E+/E-: eigenvalues for the system energy.

Demagnetization Energy

- The demagnetizing field, is the magnetic field generated by the magnetization in a magnet.
- The total magnetic field = demagnetizing field + any other field caused by free or displacement currents.



Demag and Simple Demag

- Demag function assumes the magnetization is constant in each cell, and computes the average demagnetization field.
- Simple demag function does not use any of the of the symmetries inherent in the demagnetization kernel.

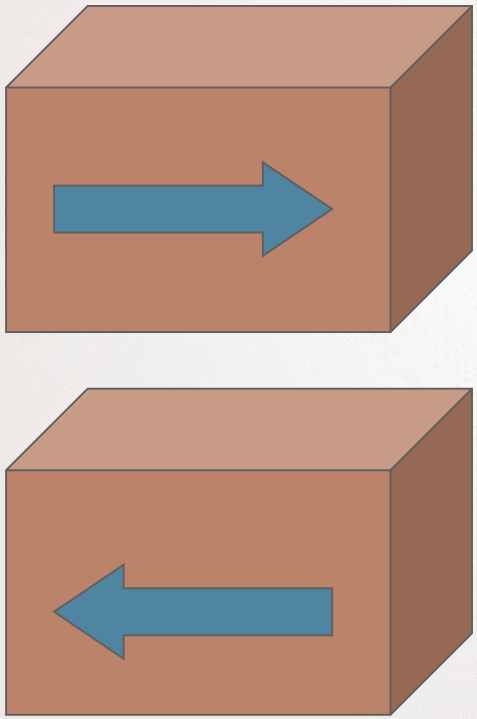
	Demag	Simple Demag
Source code	Complex	Simple
Performance	Ideal)	Poor (
Memory usage	Ideal)	Poor (

Zeeman Energy

- Zeeman energy, or the external field energy, is the potential energy of a magnetised body in an external magnetic field.
- Two choices, time-invariant Zeeman energy and object-invariant Zeeman energy.

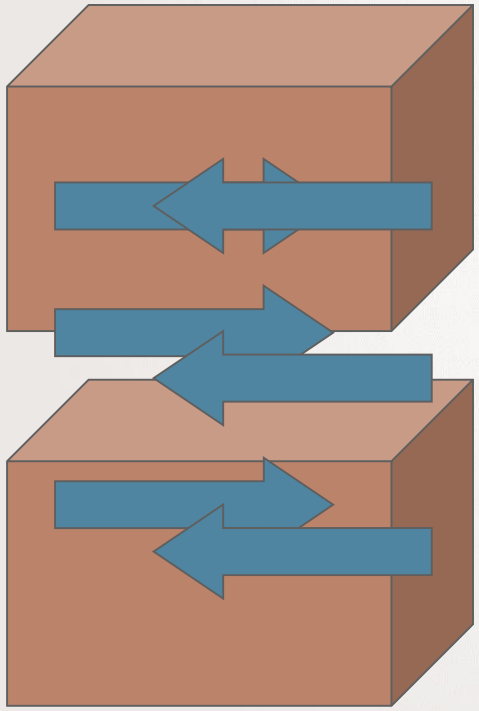
Time-invariant Zeeman

- Energy does not change with respect to time
- Can be different with different objects
- Inputs are the H field values for different objects.



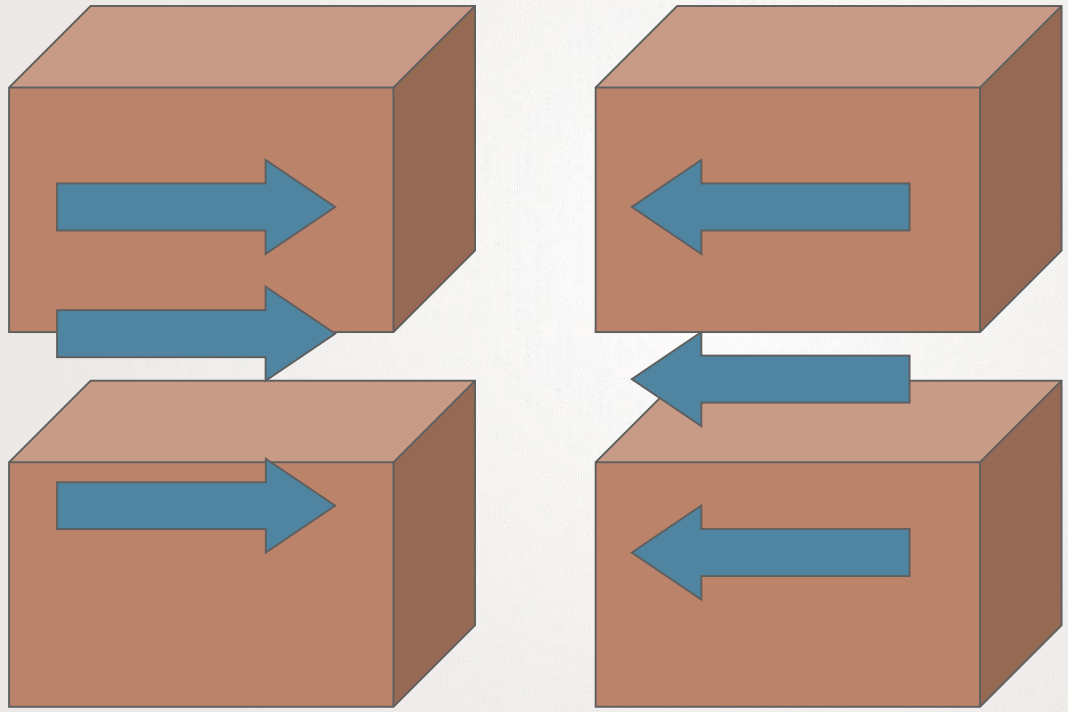
Object-invariant Zeeman

- Change with respect time (steps)



Object-invariant Zeeman

- Inputs: 7 values for each energy sweep (energy changes its direction).



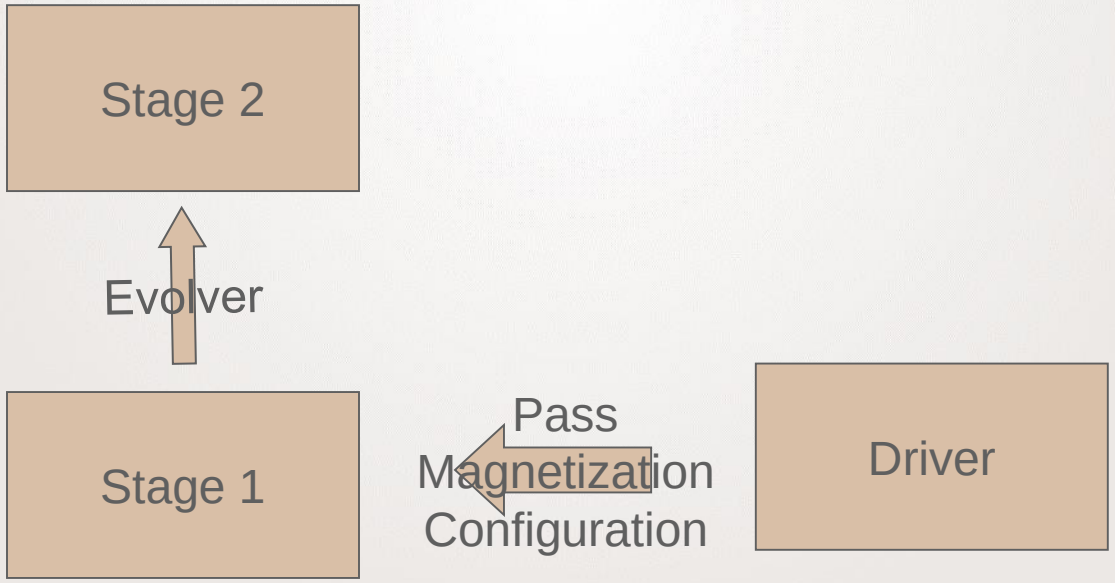
- [1 0 0 -1 0 0 5]

Evolver and Drivers

- Evolvers are responsible for updating the magnetization configuration from one step to the next.
- time evolvers - Landau-Lifshitz-Gilbert dynamics
- minimization evolvers, which locate local minima in the energy surface through direct minimization techniques.
- Evolvers are controlled by drivers and must be matched with the appropriate driver type

Evolvers and Drivers

- The drivers hand a magnetization configuration to the evolvers with a request to advance the configuration by one step
- The drivers determine when a simulation stage or run is complete



Evolvers & Drivers

Evolvers	Drivers
Euler Evolver	Time Driver
Runge-Kutta Evolver	Time Driver
CG Evolver	Min Driver

Time Evolver

Min Evolver

Evolvers

- Euler Evolver
  - A simple first order forward Euler method with step size control on Landau-Lifshitz ODE
- Runge-Kutta Evolver
  - Uses Runge-Kutta methods
  - in most cases, it will greatly **outperform** the Euler Evolver
- CG Evolver
  - in-development conjugate gradient minimizer
  - Different alogrithm, compare

Drivers

- evolvers are responsible for moving the simulation forward in individual steps
- drivers coordinate the action of the evolver on the simulation as a whole, by grouping steps into tasks, stages and runs.
- Takes two inputs:
  - initial configuration for the magnetization unit spins
    - intial direction for the magnet.
  - Pointwise Saturation Magnetization
    - The state when an increase in external H field does not increase the magnetization further.

References

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- http://www.irm.umn.edu/hg2m/hg2m_c/hg2m_c.html
- http://www.simotecthailand.co.th/en/knowledge8.html
- http://math.nist.gov/oommf/doc/userguide12a5/userguide/Standard_Oxs_Ext_Child_Clas.html#CG
- https://en.wikipedia.org/wiki/Zeeman_energy
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- https://en.wikipedia.org/wiki/Magnetocrystalline_anisotropy