OOMMF Examples

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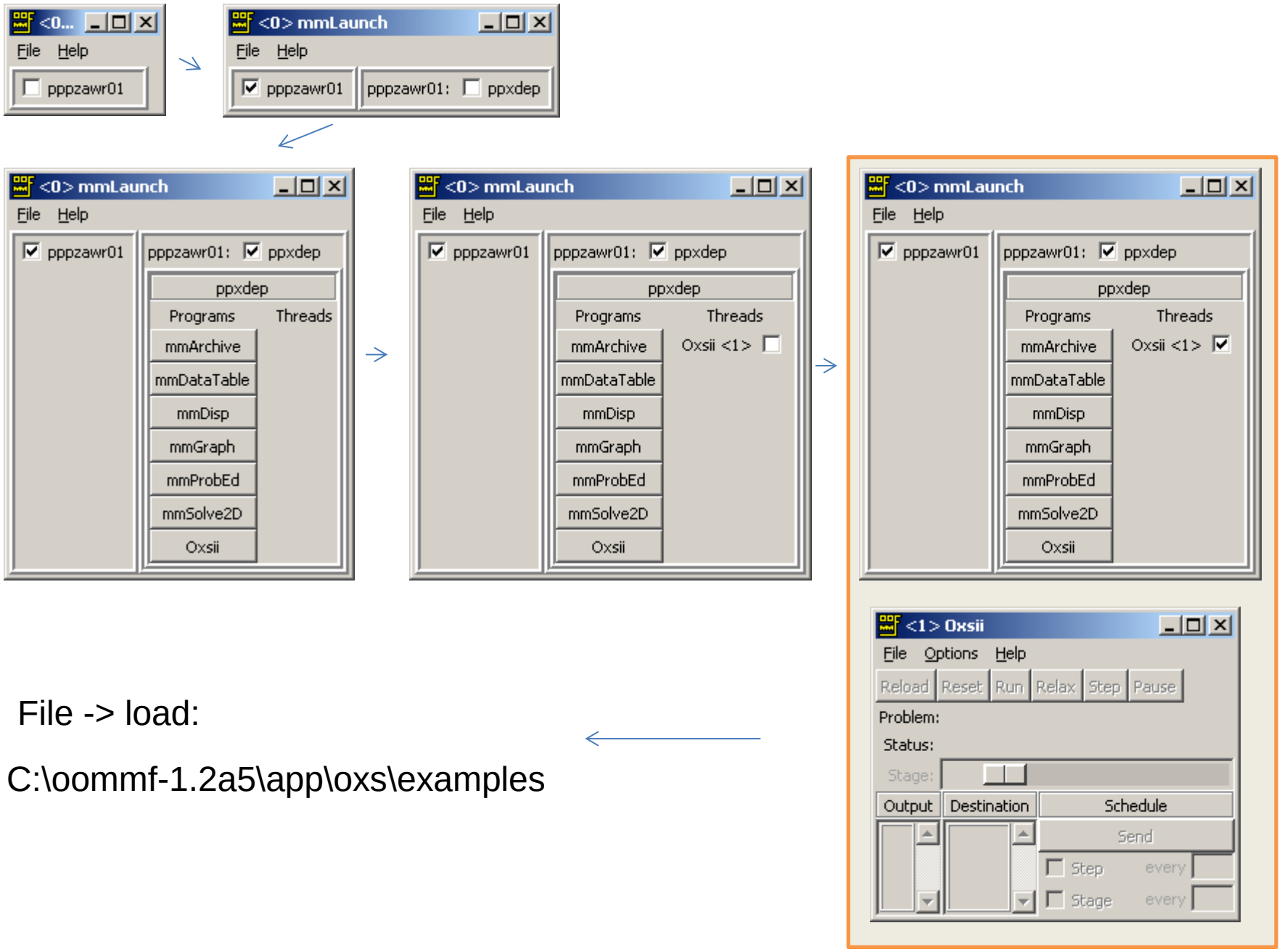
Installing OOMMF and tcl/tk

- Get oommf:
- http://math.nist.gov/oommf/ (Get the most recent version – even if it an alpha version)
- Install tcl/tk:
- **Windows:**
- http://www.activestate.com/activetcl/downloads (Make sure you get the right version for the version of OOMMF you downloaded).
- Install tcl/tk
- Unzip and run OOMMF
- **Linux:**
- http://deparkes.wordpress.com/2012/06/02/installing-oommf-on-ubuntu-11-04/



File -> load:

C:\oommf-1.2a5\app\oxs\examples

C:\oommf-1.2a5\app\oxs\examples
exchspring.mif

exchspring.mif [C:\oommf-1.2a5\app\oxs\examples] - Notepad2-mod

File Edit View Settings ?

```
# MIF 2.1
# MIF Example File: exchspring.mif
# Description: Exchange spring example
set pi [expr 4*atan(1.0)]
set mu0 [expr 4*$pi*1e-7]

Specify Oxs_MultiAtlas:atlas {
   atlas { Oxs_BoxAtlas {
        xrange {0 300e-9}
        yrange {0 300e-9}
        zrange {49e-9 98e-9}
        name top
   }  }
   atlas { Oxs_BoxAtlas {
        xrange {0 300e-9}
        yrange {0 300e-9}
        zrange {0 49e-9}
        name  bottom
   }  }
}

Specify Oxs_RectangularMesh:mesh {
   cellsize {10e-9 10e-9 7e-9}
   atlas :atlas
}

Specify Oxs_Exchange6Ngbr:NiFe {
   atlas :atlas
   A  {
```

Ln 17 / 88 Col 23 / 80 Sel 0 Sel Ln 0 1.56 KB

Multiple layers

exchspring.mif [C:\oommf-1.2a5\app\oxs\examples] - Notepad2-mod

File Edit View Settings ?

```
Specify Oxs_RungeKuttaEvolve:evolver {
  alpha 0.5
}

Specify Oxs_TimeDriver {
  basename exchspring
  evolver :evolver
  comment {1 deg/ns = 17453293 rad/sec; If Ms=8.6e5, and lambda is small,
           then mxh=1e-6 translates into dm/dt = 2e5 rad/sec = 0.01 deg/ns}
  stopping_dm_dt 1
  mesh :mesh
  Ms  { Oxs_AtlasScalarField {
      atlas :atlas
      values {
         top 860e3
         bottom 1400e3
      }
  }}
  m0 { Oxs_AtlasVectorField {
     atlas :atlas
     norm 1
     values {
         top    { -1 10 0 }
     bottom { 10  1 0 }
     }
   }}
}
```

Ln 54 / 88 Col 34 / 80 Sel 0 Sel Ln 0 1.56 KB ANSI LF INS Shell Script

Set initial magnetisation

exchspring.mif [C:\oommf-1.2a5\app\oxs\examples] - Notepad2-mod

File Edit View Settings ?

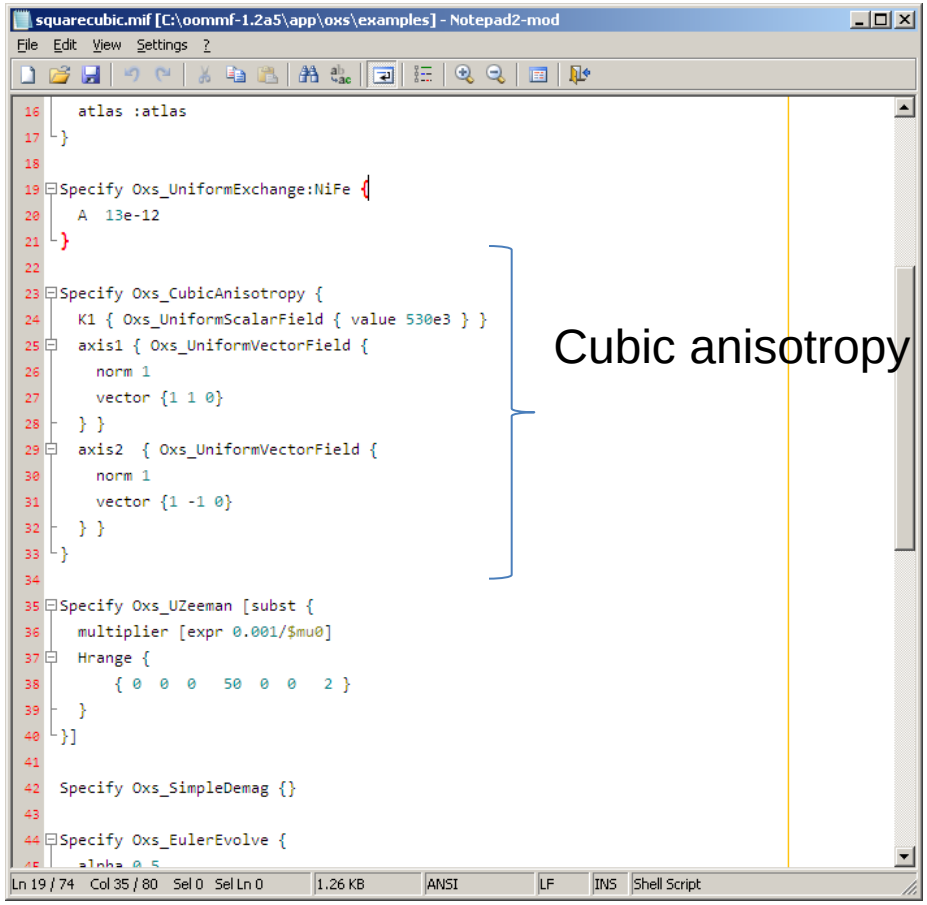
```
    top bottom 20e-12
    bottom bottom 30e-12
  }
}

Specify Oxs_UniaxialAnisotropy {
  K1 { Oxs_AtlasScalarField {
    atlas :atlas
    values {
        top 0
    bottom 520e3
    }
  }}
  axis { Oxs_UniformVectorField {
    norm 1
    vector {1 0 0}
  } }
}

Specify Oxs_UZeeman [subst {
  multiplier [expr 0.001/$mu0]
  Hrange {
     {    0   0  0   500  50  0   10 }
     {  500  50  0  -500 -50  0   20 }
     { -500 -50  0   500  50  0   20 }
  }
}]

Specify Oxs_Demag {}
```

7 / 88 Col 23 / 80 Sel 0 Sel Ln 0 1.56 KB ANSI LF INS Shell Script

Uniaxial anisotropy

Applied field

Squarecubic.mif



Cubic anisotropy

Imageatlas.mif

imageatlas.mif [C:\oommf-1.2a5\app\oxs\examples] - Notepad2-mod

File Edit View Settings ?

```
# MIF 2.1
# MIF Example File: imageatlas.mif
# Description: Example use of the Oxs_ImageAtlas class.
#
set pi [expr 4*atan(1.0)]
set mu0 [expr 4*$pi*1e-7]

RandomSeed 1

Specify Oxs_ImageAtlas:atlas {
  xrange {0 320e-9}
  yrange {0 320e-9}
  zrange {0  20e-9}
  viewplane xy
  image vortex.bmp
  colormap {
     magenta  region_1
     cyan     region_2
     yellow   region_3
     red      region_4
     blue     region_5
     green    region_6
     white    vacuum
  }
}
```

Image sets regions

imageatlas.mif [C:\oommf-1.2a5\app\oxs\examples] - Notepad2-mod

File Edit View Settings ?

```
}

Specify Oxs_UniaxialAnisotropy {
  K1 { Oxs_AtlasScalarField {
     atlas :atlas
     default_value 50e3
     values {
        region_2  -10e3
        region_4  -10e3
        region_6  -10e3
        vacuum      0
     }
  }}
  axis { Oxs_AtlasVectorField {
     atlas :atlas
     values {
        region_1  {-1.0   0.7  0}
        region_2  {-1.0  -0.2  0}
        region_3  {-0.7  -1.0  0}
        region_4  { 1.0  -0.5  0}
        region_5  { 1.0   0.2  0}
        region_6  { 0.6   1.0  0}
        vacuum    { 0     0    1}
     }
     norm 1.0
  }}
}

Specify Oxs_UZeeman [subst {
```

Ln 37 / 99 Col 29 / 80 Sel 0 Sel Ln 0 1.73 KB ANSI LF INS Shell Script

Different anisotropy depending region

imageatlas.mif [C:\oommf-1.2a5\app\oxs\examples] - Notepad2-mod

File Edit View Settings ?

```
Specify Oxs_CGEvolve {}

Specify Oxs_MinDriver {
  basename imageatlas
  evolver Oxs_CGEvolve
  stopping_mxHxm 0.1
  mesh :mesh
  Ms { Oxs_AtlasScalarField {
     atlas :atlas
     default_value 8e5
     values {
        vacuum 0
     }
  }}
  m0 { Oxs_AtlasVectorField {
     atlas :atlas
     values {
        region_1  {-1.0   0.7  0}
        region_2  {-1.0  -0.2  0}
        region_3  {-0.7  -1.0  0}
        region_4  { 1.0  -0.5  0}
        region_5  { 1.0   0.2  0}
        region_6  { 0.6   1.0  0}
        vacuum    { 0     0    1}
     }
     norm 1.0
  }}
}
```

Ln 81 / 99 Col 12 / 80 Sel 0 Sel Ln 0 1.73 KB ANSI LF INS Shell Script

Different M0 depending on region

Varalpha.mif

varalpha.mif [C:\oommf-1.2a5\app\oxs\examples] - Notepad2-mod

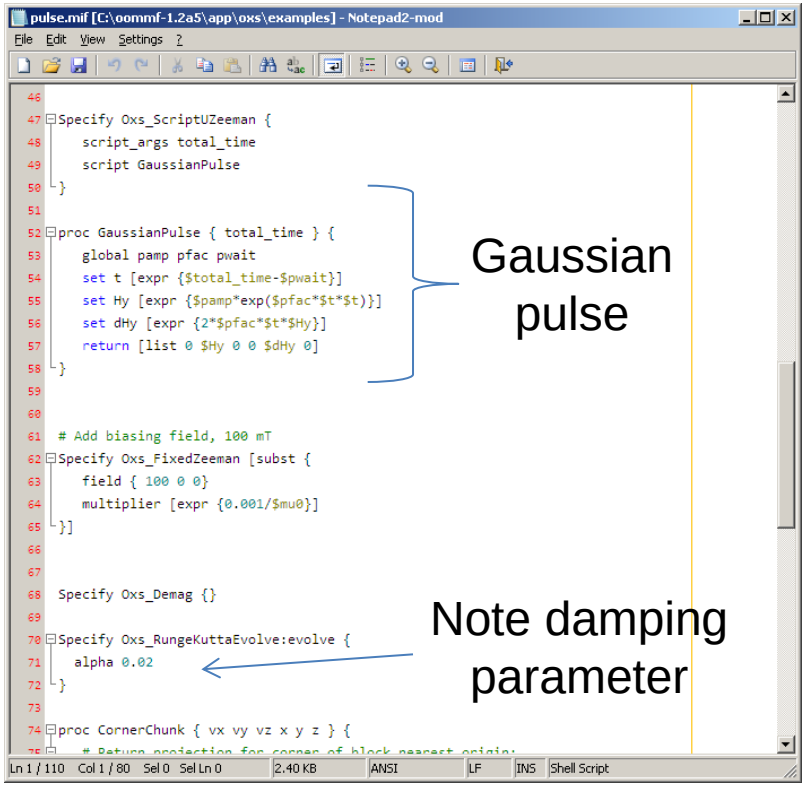
File Edit View Settings ?

```
}

Specify Oxs_UniformExchange {
   A  13e-12
}

# For simplicity, no demag
Ignore Specify Oxs_Demag {}

# Time varying applied field
set Hw [expr {2*$pi*$H_freq*1e9}]  ;# Convert freq from GHz to radians/sec
proc Happ { t } {
   # Import time is in seconds.
   # Return value is field in mT.
   global H_amp Hw
   set Hy [expr {$H_amp*sin($Hw*$t)}]
   set dHy_dt [expr {$Hw*$H_amp*cos($Hw*$t)}]
   return [list 0. $Hy 0. 0. $dHy_dt 0.]
}
Specify Oxs_ScriptUZeeman [subst {
   script_args total_time
   script Happ
   multiplier [expr {1.0/(1000.*$mu0)}]
}]


# Spatially varying damping parameter alpha
proc alphascript { x y z } {
   global alphamin alphamax
   return [expr {$alphamin + ($alphamax-$alphamin)*$yl]
```

Ln 1 / 87 Col 1 / 80 Sel 0 Sel Ln 0 1.76 KB ANSI LF INS Shell Script

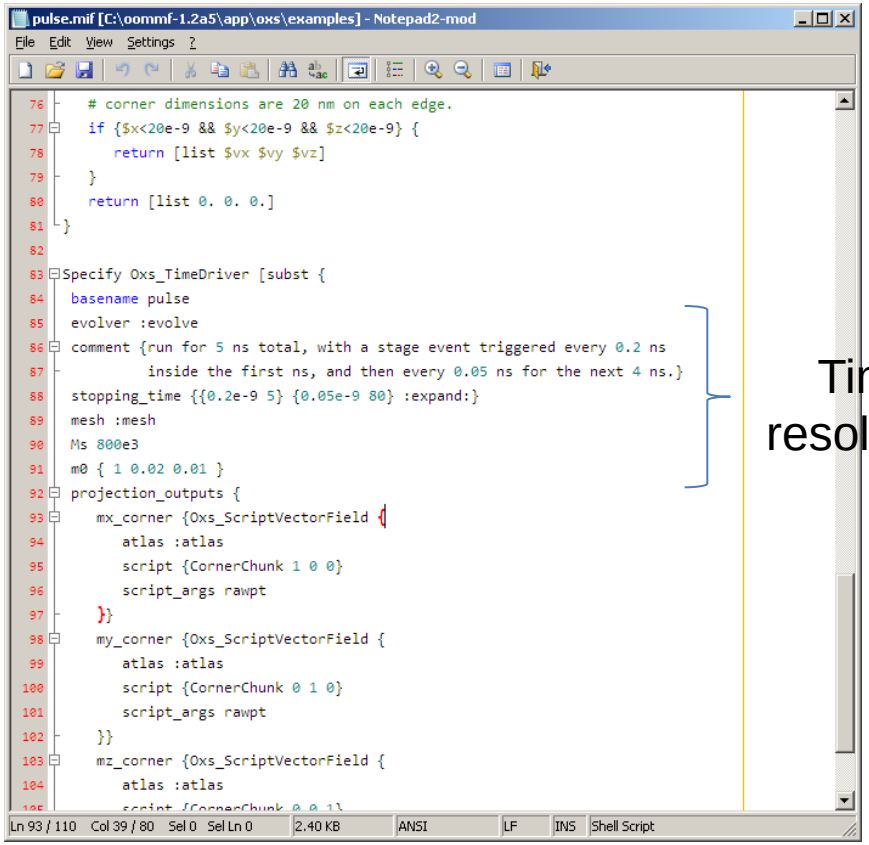
Time varying field

Pulse.mif



Gaussian pulse

Note damping parameter



Time resolution

One of my own:

DepinningFieldsDynamic_v2.mif [C:\hpc\ppxdep\experiments\oommf\depinning_fields\problems] - Notepad...

File Edit View Settings ?

```
#Specify that the script should determine the demagnetising term.
Specify Oxs_Demag {}

Specify Oxs_RungeKuttaEvolve {
  alpha {Oxs_AtlasScalarField {
  atlas :atlas
  values {
    L2R 0.02
    R2L 0.02
    L2R_taper 0.5
    R2L_taper 0.5
    universe 0
    notch 0
}
}}
  do_precess 1
  start_dm 0.01
  min_timestep 1e-15
  max_timestep 1e-15
}

# ---- Set us up the time driver ----
# Should be of the form:
#Specify Oxs TimeDriver:name {
#evolver evolver spec
#mesh mesh spec
#Ms scalar field spec
#m0 vector field spec
#stopping dm dt torque criteria
```

Ln 1 / 280 Col 1 / 80 Sel 0 Sel Ln 0 6.37 KB ANSI LF INS Shell Script

Set time evolution

DepinningFieldsDynamic_v2.mif [C:\hpc\ppxdep\experiments\oommf\depinning_fields\problems] - Notepad...

File Edit View Settings ?

```
#stage count check test
#basename base file name
#scalar output format format
#vector field output format { style precision }
#}
# Can replace Ms scalar field with a random field one. See doc for details.
# If you just want the simulation to run until ~static use stopping_dm_dt.
# According to the help a value of 0.1 - 1.0 is reasonable.
Specify Oxs_TimeDriver [ subst {
 evolver Oxs_RungeKuttaEvolve
 stopping_dm_dt 1.0
 mesh :mesh
 checkpoint_file $checkpoint
 checkpoint_cleanup done_only
 Ms {Oxs_AtlasScalarField {
   atlas :atlas
   values {
     universe 0
     L2R $Ms
     R2L $Ms
    L2R_taper $Ms
    R2L_taper $Ms
    notch 0


 } } }

 m0 { Oxs_FileVectorField {
    atlas :atlas
```

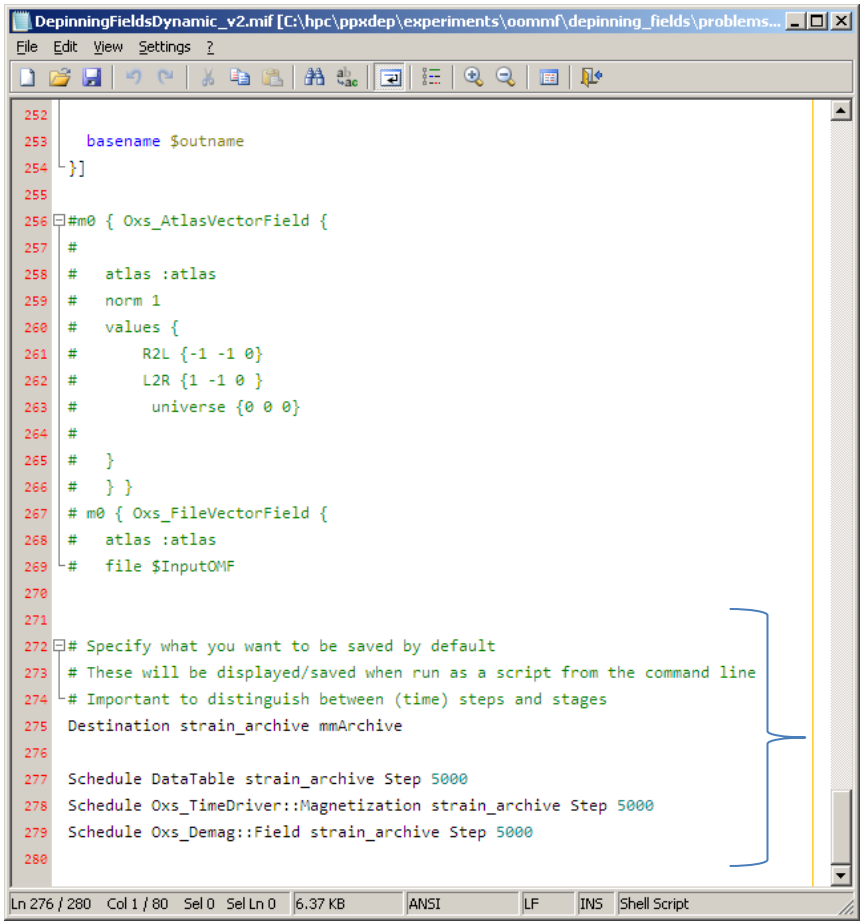
Ln 219 / 280 Col 30 / 80 Sel 0 Sel Ln 0 6.37 KB ANSI LF INS Shell Script

Set stopping condition

Analysis

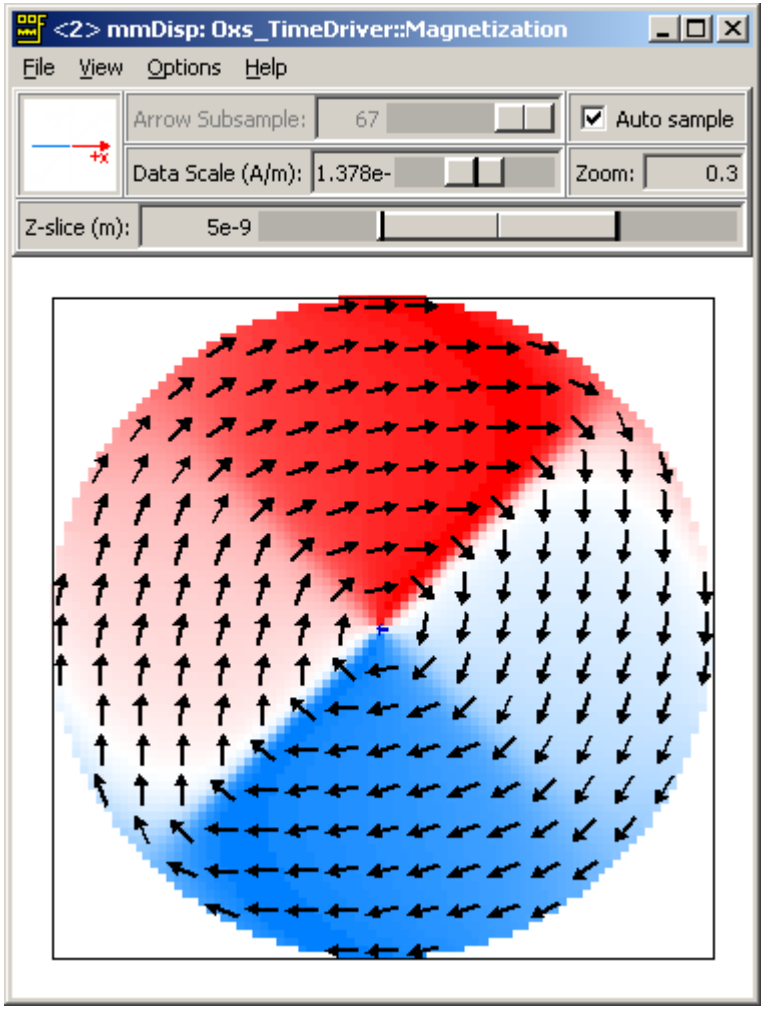
- Making sure we get the right outputs
- Built-in OOMMF tools
- OOMMFTools

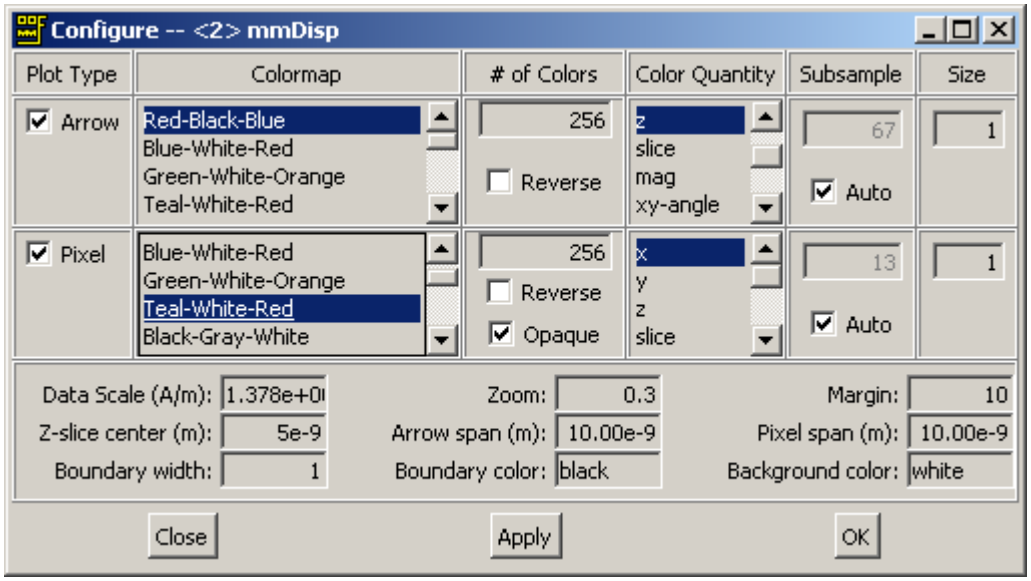
Setting automatic output:



Saves output every 5000 steps (in this case 1 step = 1ps)

Built-in analysis





Can save as bitmap
Also command line tools, but...

Other analysis

Contributed software: http://math.nist.gov/oommf/contrib/

OOMMFTools

Command line

https://github.com/deparkes/OOMMFTools/tree/develop/OOMMFTools-src

GUI

omf2mat.py bmp2avi.py

odt2dat.py

Also https://github.com/deparkes/scripts/

mat2velocity.m

mat2strayfield.m

First attempts at processing in matlab

avf2bmp.py

Convert oommf vector output to

master_depinning.py Master script for several processing scripts

Things to watch out for:
- Staircase discretisation: non-90-degree angles will have steps in them
- Cell size: generally needs to be below exchange length for accurate calculation

$$l_1 = \sqrt{\frac{2A}{\mu_0 M_s^2}} \qquad l_2 = \sqrt{\frac{A}{K_1}}$$

Sources of help

- OOMMF manual (comes with oommf download)
- muMag mailing list
  http://www.ctcms.nist.gov/~rdm/mumag.org.html
- deparkes.wordpress.com
- OOMMF example files

References

Parallelizing a Micromagnetic Program for Use on Multiprocessor Shared Memory Computers ieee trans magn 45 10 2009

J. Fidler, R. W. Chantrell, T. Schrefl, M. Wongsam, and J. Fidler, "Micromagnetics I: Basic principles," Encyclopedia of Materials: Science and Technology, K. H. J. Buschow, R. W. Cahn, M. C. Flemings, B. Ilschner, E. J. Kramer, S. Mahajan (eds.), Elsevier, 2001, pp. 5642-5651.

http://magnet.atp.tuwien.ac.at/ts/papers/ema108015.pdf

Numerical Micromagnetics: Finite Difference Methods
Micromagnetism
Fundamentals of Micromagnetism and Discrete Computational Models
Jacques E. Miltat[1],
Michael J. Donahue[2]

Resources

- http://magnetism.eu/esm/2009/abs/chubykalo-abs2.pdf
- Analytical micromagnetics: http://magnetism.eu/esm/2009/slides/fruchart-tutorial.pdf
- http://nmag.soton.ac.uk/nmag/0.2/manual/html/tutorial/doc.html