

DEPARTMENT OF SOLID STATE SCIENCES DYNAMAT GROUP

MUMAX3-WORKSHOP

SESSION 2

Dr. Jonathan Leliaert, Dr. Jeroen Mulkers











Monday 08/31, 6PM-8PM CET

Session 1: general introduction to micromagnetics in mumax3

Session 2: mumax3 ecosystem, workflow and a first simulation

Monday 09/07, 6PM-7:30PM CET

Session 3: basic examples

>homework

Monday 09/14, 6PM-7:30PM CET

Session 4: advanced features and more extensive examples



1. Installing mumax3

- Windows
- Linux
- 2. Mumax3 website
 - Home
 - Download
 - Examples
 - API
 - Forum

- 3. Workflow
 - Running a simulation: standard problem 4
 - (Processing) output
 - Mumax3-convert
 - Mumax-view
- 4. Extra's
 - Run flags
 - Benchmark
 - No GPU ->google collab



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INSTALLING MUMAX3

- We assume you have computer running windows or linux,
- With an NVIDIA GPU with compute capability >= 3.0,
- For which the drivers are installed already and up to date!
- Installation in a few (very similar) steps for Windows or Linux:
 - find driver version
 - download binary from http://mumax.github.io/download.html
 - add mumax3 directory to your \$PATH
 - (optionally) install gnuplot



INSTALLING MUMAX3 ON LINUX

- find driver version, either via nvidia-smi or in nvidia-settings

F	jleliaer@sleipnyr: ~	Q = _ 0 😣	N	IVIDIA X Server Settings	- - ×
jleliaer@sleipnyr:~\$ nvidia-smi Fri Aug 28 15:46:50 2020 +			X Server Information X Server Display Configuration	F	
NVIDIA-SMI 450.66 Driver Version: 450.66 CUDA Version: 11.0			X Server XVideo Settings		NIDIA
GPU Name Persistence- Fan Temp Perf Pwr:Usage/Ca 	M Bus-Id Disp.A Vo p Memory-Usage GPU 	latile Uncorr. ECC U-Util Compute M. MIG M.	OpenGL Settings Graphics Information Antialiasing Settings	System Information	Linux-x86 64
0 TITAN RTX Off 41% 37C P8 22W / 280W 	00000000:01:00.0 On 209MiB / 24217MiB 	N/A 3% Default N/A	VDPAU Information GPU 0 - (TITAN RTX) Thermal Settings	NVIDIA Driver Version: X Server Information Display Name:	450.66 sleipnyr:1
1 TITAN Xp Off 23% 30C P8 8W / 250W 	00000000:07:00.0 Off 11MiB / 12196MiB 	N/A 0% Default N/A	HDMI-0 - (DELL P2311H) GPU 1 - (TITAN Xp) Thermal Settings	Server Version Number: Server Vendor String: Server Vendor Version:	11.0 The X.Org Foundation 1.20.8 (12008000)
*		+	PowerMizer	NV-CONTROL Version:	1.29
+ Processes: GPU GI CI PID Ty ID ID	ype Process name	GPU Memory Usage	Application Profiles nvidia-settings Configuration	Screens:	1
0 N/A N/A 995 0 N/A N/A 1940 0 N/A N/A 2145 1 N/A N/A 995	G /usr/lib/xorg/Xorg G /usr/lib/xorg/Xorg G /usr/bin/gnome-shell G /usr/lib/xorg/Xorg	35MiB 76MiB 84MiB 4MiB			
1 N/A N/A 1940	G /usr/lib/xorg/Xorg	4MiB			Help Quit

INSTALLING MUMAX3 ON LINUX

- download binary from http://mumax.github.io/download.html



Prerequisites

To run mumax3.10 you need

- An NVIDIA GPU with at least a compute capability 3.0
- An up to date NVIDIA driver (compatible versions given below)
- Optional: gnuplot for plots in the web GUI

Download and installation

Select the platform and the NVIDIA driver for which you want to download mumax3.





INSTALLING MUMAX3 ON LINUX

- extract the mumax3 binaries, e.g. in \$HOME/bin/mumax3.10/
- add mumax3.10 directory to your \$PATH

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🕚 Recent						
🛨 Star ed	mumax	3.10				
습 Home						
Desktop						
🗐 Documents						
$\underline{0}$ Downloads						
🎵 Music						
Pictures						
		"mumax3.1	10" selecte	ed (cont	aining 5 it	tems)





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 - Linux
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 - Home
 - Download
 - Examples
 - API
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MUMAX3 WEBSITE

• <u>http://mumax.github.io/</u>



mumax³ is a GPU-accelerated micromagnetic simulation program developed at the DyNaMat group of Prof. Van Waeyenberge at Ghent University. The code is written and maintained by Arne Vansteenkiste.

A speed-up of the order of 100x compared to CPU-based simulations can easily be reached, even with relatively inexpensive gaming GPUs. Additionally, the software is optimized for low memory use and can handle about 16 million FD cells with 2GB of GPU RAM.

Citations and licence

If you use mumax in any work or publication, we kindly ask you to cite: "The design and verification of mumax3", AIP Advances 4, 107133 (2014).

mumax³ is open-source software. You are free to modify and distribute the source code under the GPLv3 licence.



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STANDARD PROBLEM 4

- <u>https://www.ctcms.nist.gov/~rdm/mumag.org.html</u>
 - Geometry

A film of thickness, t=3 nm, length, L=500 nm and width, d=125 nm will be used.



• Field

```
\mu_0 H_x=-24.6 mT, \mu_0 H_v= 4.3 mT, \mu_0 H_z= 0.0 mT
```



STANDARD PROBLEM 4

• Input file

```
SetGridsize(128, 32, 1)
SetCellsize(500e-9/128, 125e-9/32, 3e-9)
Msat = 800e3
Aex = 13e-12
alpha = 0.02
m = uniform(1, .1, 0)
relax()
          // relaxed state
save(m)
autosave(m, 200e-12)
tableautosave(10e-12)
B_{ext} = vector(-24.6E-3, 4.3E-3, 0)
run(1e-9)
```

• Output table





MUMAX3-CONVERT-HELP

• Output formats:

-CSV output in CSV format -dump output in dump format -gif GIF output -gplot Gnuplot-compatible output -jpg JPEG output -json output in JSON format -numpy Numpy output -omf string "text" or "binary" OVF1 output -ovf string "text" or "binary" OVF1 output -ovf2 string "text" or "binary" OVF2 output -png PNG output -show Human-readible output to stdout -f string Printf format string (default "%v") -svg SVG output -svgz SVGZ output (compressed) -vtk string "ascii" or "binary" VTK output

Usage of mumax3-convert:

MUMAX3-CONVERT-HELP

• Image options

```
Usage of mumax3-convert:
  -arrows int
        Arrow size for vector bitmap image output
  -color string
        Colormap for scalar image output. (default "black,gray,white")
  -comp string
        Select a component of vector data. (0,1,2 \text{ or } x,y,z)
  -max string
       Maximum of color scale: "auto" or value. (default "auto")
  -min string
       Minimum of color scale: "auto" or value. (default "auto")
  -normalize
        Normalize vector data to unit length
  -normpeak
        Scale vector data, maximum to unit length
  -o string
        Save all output in this directory
  -resize string
        Resize. E.g.: 128x128x4
  -xrange string
        Crop x range min:max (both optional, max=exclusive)
  -yrange string
        Crop y range min:max (both optional, max=exclusive)
  -zrange string
        Crop z range min:max (both optional, max=exclusive)
```



MUMAX-VIEW

www.mumax.ugent.be/mumax-view



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MUMAX3 - HELP

```
jonathan@monster3:~$ mumax3 -h
Usage of mumax3:
 -cache string
       Kernel cache directory (empty disables caching) (default "/tmp")
 -f
       Force start, clean existing output directory
 -failfast
       If one simulation fails, stop entire batch immediately
  -gpu int
       Specify GPU
 -http string
       Port to serve web gui (default ":35367")
       Open interactive browser session
  -i
 -o string
       Override output directory
  -test
       Cuda test (internal)
       Print version (default true)
  -v
  -vet
       Check input files for errors, but don't run them
```





http://mumax.github.io/index.html



Benchmark:

https://github.com/mumax/3



* generously sponsored by the NVIDIA corporation on the occasion of this workshop

Throughput (M cells/s) 800 GTX 970 GTX 580 V100 K20X M40 TITAN V M2070 C2050 P40Quadro K4200 **GTX 480** GTX 680 GTX 980 GTX 1070 GTX TITAN BLACK GTX 1080 **JTX 980 Ti** P100 650M **GTX 660** GTX 1060 (Laptop) **STX TITAN** Quadro P5000 **GTX TITAN X** GTX 1080 Ti **TITAN Xp** RTX 2080 Ti **GT 755N GTX 860**M 700 GT 600 500 400 300 200 100 0 0 n/a n/a n/a n/a n/a n/a n/a n/a n/a 0.2 0.4

Throughput/Price (M cells/s)/USD



"Tomorrow's micromagnetic simulations ", Journal of Applied Physics 125, 180901 (2019);

https://doi.org/10.1063/1.5093730





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GOOGLE COLLABORATORY

- If you do not have access to a machine which has a CUDA enabled graphics card, you can still try out the examples for yourselves, by running mumax3 in a google collaboratory session for free.
- The only thing you will need to get this working is a gmail account.
- <u>https://colab.research.google.com/github/JeroenMulkers/mumax3-tutorial/blob/master/mumax3.ipynb</u>



mumax.ugent.be



• mumax3 website

mumax3 workshop

- mumax-view
- mumax mailing list
- dynamat website

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jeroen.mulkers@ugent.be

Homework

- Install mumax3
- Check if it works by running standard problem 4
- If your GPU is not listed on our homepage yet, run the benchmark input file
- Send the resulting "benchmark.txt" file to jonathan.leliaert@ugent.be with subject
 - "mumax3 benchmark GPU_name" and specify which version you used by adding the output of mumax3 -test _____







