Granular and other soft matter: Probe experimentally using NMR/MRI

In NMR/MRI, the sample is placed in a strong magnetic field, and then radio-frequency and field gradient pulses are used to probe the motion of hydrogen nuclei.

To date and in progress:
- Vibrofluidized granular bed
- Gas-fluidized granular bed
- Granular flow through a vertical channel

Planned and future:
- Foams
- Emulsions?
- Gels?
- Bio matter?

In granular fluids, heat can flow from cold to hot.
Candela-group research:
Granular/soft matter; quantum fluids and solids

Quantum fluids and solids: Experiments on helium systems at extremely low temperatures and high magnetic fields

To date and in progress:
• Magnetization transport (NMR): field=temperature??
• Momentum transport (viscosity): giant enhancement at very high $B/T$
• Probe “supersolid” via 3He impurities

Planned and future:
• Hyperpolarized contrast agents for MRI?

Top-loading dilution refrigerator with 10T magnet, recently installed in Hasbrouck 115

High $B/T$ facility at U of Florida
Recent experiments in the field of Quantum Solids have suggested that solid $^4\text{He}$ may be a "supersolid". That is mass flux may take place through the solid. This is very controversial, with other possible interpretations.

So, we want to see if this is true.
Something very interesting is happening in solid helium!

Mike Ray – received his Ph.D. working on this project.
Physics of Nanoscale Devices and Materials

- A brief overview

Mark Tuominen
How to make nanostructures?

"Top-Down" Methods

- Sample
- Cooling pipe
- LN$_2$
- Mask
- Lithography, deposition, etch
- Source
- Collimator

"Bottom-Up" Methods

- Guided self-assembly
- Or nature made
- Geobacter
What physics? Examples - part 1

Electron transport in nanostructured materials

Biological nanowires

Proton transport in solids

- electronic conductors
- metallic, but organic
- tunable conductance


Artificial Kondo lattice (PRB 2011)


- relevant to fuel cells and biology
What physics? Examples - part 2

**Nanomagnetism**

![Magnetization Diagram]

$M_z$ or $M_z$

$H$

Science, PRB, APL, Nanotech. (2000s)

**Superconducting devices**

vortices in coupled superconductors

superconducting single-electron tunneling transistors

**Ultrahydrophobic surfaces**

lotus leaf effect; Adv. Funct. Mat. 2011