Teaching with Neutrons: Labs, Courses, and Student Research Projects at the McMaster Nuclear Reactor

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The McMaster Nuclear Reactor (MNR)

- 5 MW “swimming pool” reactor on campus at McMaster University

- As of April, 2018: Canada’s largest research reactor and most powerful source of neutron beams → unique tool for teaching physics
The McMaster Nuclear Reactor (MNR)

- MNR is a **multi-purpose** research reactor
- Used for production of medical isotopes, neutron irradiation and activation analysis, neutron radiography, neutron scattering, education and training
Physics Education with Neutrons

Opportunities at MNR for:
• Student Research Projects
• Co-op Students/Summer Internships
• Reactor Tours
• Demonstrations and Lab Experiments
• Summer Schools/Short Courses (undergraduate or graduate level)
Initial Focus: Neutron Scattering

1. Powerful technique for investigating properties of materials
2. Connects to broad range of physics concepts
3. Important part of Canadian physics history

\[ \mathbf{E}_{f}, \mathbf{k}_{f} \]
\[ \mathbf{E}_{i}, \mathbf{k}_{i} \]
\[ \mathbf{Q} \]
\[ 2\theta \]
McMaster Alignment Diffractometer (MAD)

- Primary instrument for teaching purposes
- Triple-axis neutron spectrometer located on Beamport 6 at MNR

- Built on site of Brockhouse’s original McMaster triple-axis instrument
Example Lab: Neutron Diffraction

• **Objective:** measure elastic scattering (i.e. diffraction) from both single crystal and powder samples.

• Experiment designed for ~3 hour timeslot with overnight data collection. Can be tailored for 2nd year undergrad to graduate level.

\[ n\lambda = 2d \sin \theta \]
(Bragg’s Law)

(2,0,0) Diffraction Peak
Objective: measure elastic scattering (i.e. diffraction) from both single crystal and powder samples.

Experiment designed for ~3 hour timeslot with overnight data collection. Can be tailored for 2nd year undergrad to graduate level.

Example Lab: Neutron Diffraction

$Y_2O_3$ Powder Sample

Space Group $Ia\bar{3}$

$(a = 10.606 \text{ Å})$
Example Lab: Neutron Spectroscopy

- **Objective:** measure inelastic scattering from lattice vibrations (i.e. phonons) in a single crystal of copper.
- Experiment designed for ~3 hour timeslot followed by 1-2 days data collection. Can be tailored for 3rd/4th year undergrad to graduate level.
How can you use MNR in your courses?

If you are in the local area:

• Come and visit MNR in person

• Can accommodate groups of up to 10 students at a time

• Staff/TA support available

• Experiments can be combined with related activities (lectures, health physics training, multiple labs, tours of other facilities, etc)
How can you use MNR in your courses?

If you are farther away:

- Come and visit MNR in person (extended visit?)
- Options for “mail in” samples and remote data collection
- Recorded video content and livestreaming of experiments currently under development
How Can You Reach Us?

• For reactor tours:
  McMaster Nuclear Reactor
  1280 Main Street West
  Hamilton, Ontario
  L8S 4M1
  nuclear.mcmaster.ca

• For neutron scattering experiments or labs:
  Pat Clancy (clancyp@mcmaster.ca)
  Or: macneutrons@gmail.com