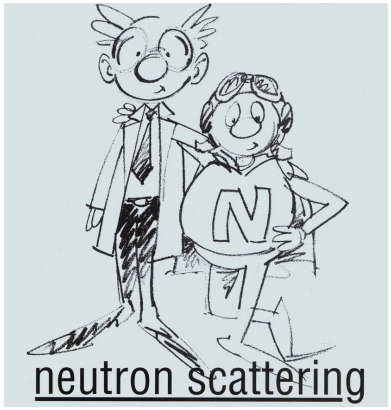
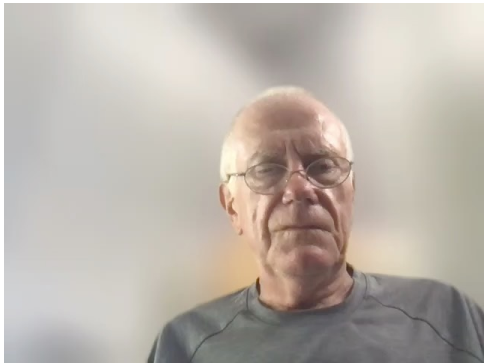


Planning a Neutron or X-Ray Scattering Experiment

by

Roger Pynn
Indiana University and Oak Ridge National Lab

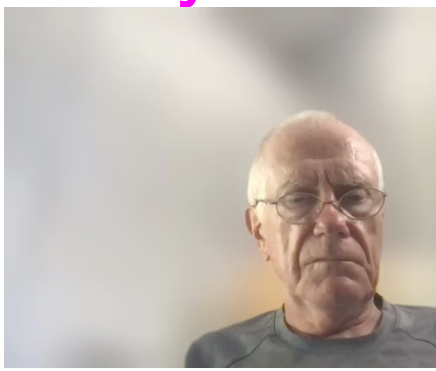


Advantages and Disadvantages of Neutrons

- Neutron advantages: 
  - Wavelength comparable with interatomic spacings
  - Kinetic energy comparable with that of atoms in a solid
  - Penetrating => bulk properties are measured & sample can be contained
  - Weak interaction with matter aids interpretation of scattering data
  - Isotopic sensitivity allows contrast variation
  - Coherent scattering for diffraction & incoherent scattering for self-motion
  - Neutron magnetic moment couples to ***B*** => neutron "sees" unpaired electron spins
  - Provides statistical information rather than real-space pictures
  - Neutrons do not destroy samples

- Neutron Disadvantages/Issues 
  - Neutron sources are weak => low signals, need for large samples etc
  - Some elements (e.g. Cd, B, Gd) absorb strongly
  - Kinematic restrictions (can't access all energy & momentum transfers)
  - Provides statistical information rather than real-space pictures
  - Many investigations that used to be the domain of neutrons (e.g. inelastic scattering, magnetic scattering) can now be done to some extent by x-rays because x-ray sources are so much more intense

Advantages and Disadvantages of X-Rays



- Advantages 
  - λ similar to interatomic spacings
  - High brilliance x-ray sources (coherence, small beams etc)
  - No kinematic restrictions (Q and E not coupled)
  - No restriction on energy transfer that can be studied
  - Orbital and spin components of magnetic scattering can be separated

- Disadvantages 
  - Strong absorption of low energy photons
  - Contrast issues (low contrast for different hydrocarbons, scattering ~ Z^2)
  - Radiation damage to samples
  - Magnetic scattering is weak except at resonances resonances
  - Energy resolution limited for inelastic scattering

What experiment should I do?

- Of course it depends on the science
  - Cross sections: x-rays see electrons while neutrons see nuclei and B
  - For neutrons: coherent, incoherent, absorption (also n-gamma…)
  - X-rays: Thomson, magnetic, absorption (also XAFS….)
  - Sample size – neutrons generally require larger samples
  - "Atomic labelling" – isotopes for neutrons, absorption edges for x-rays
  - Resolution – varies by technique
  - Sample environment – neutrons penetrate easily; diamond anvils for x-rays
  - Often either x-rays or neutrons can be used but facilities prefer experiments that exploit their unique capabilities
  - Check what is already known and where the experiments were done
  - Facility web sites have details of all their instrument capabilities – read these first
  - Contact instrument scientists and discuss your proposed experiment, even if it is just a germ of an idea

How do I prepare?

- Decide which facility
  - Instrument capabilities may be the determining factor
  - Science is a social activity – has the facility done experiments like yours? Did you establish a good rapport with the instrument scientist?
- Write a proposal
  - Spend time on this, especially if it's your first
  - The general outline is always the same:
    - What is the phenomenon? Why do we care? What do we do about it?
    - Exactly what experiment are we going to do? How are we going to analyze the data? How many samples will we measure? How long will each measurement take? How do we know that? What sample environment will we use? Who will provide it?
    - Is the sample already available? If not, how can we guarantee that it will be ready for the experiment? Will I need a sample prep lab at the facility?
    - What measurements have we (or others) already made on this sample?
    - What is our level of experience/ expertise/ competence?

What to expect

of training. Try to do as much as possible on line
re you go

- Arrange to arrive early if you need to prepare samples
- Think through your experiment before & during
  - Remember, things break. You want to make sure you have essential data early during your beam time – calibrations on the last day are sometimes not wise
  - Do as much data analysis during the experiment as you can. Think about what your measurements mean and what else you need (including statistics) to make sense of them
- Ask for advice –many experienced people at all facilities
- While all facilities store data and metadata, you still need to keep notes, as you would in a lab
- Make sure you know and follow safety rules & rules for disposing of samples

General References

- Neutron Scattering: A Non-Destructive Microscope for Seeing Inside Matter
  by Roger Pynn
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  by D.S. Sivia
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- Introduction to the Theory of Thermal Neutron Scattering
  by G. L. Squires

- Elements of Modern X-Ray Physics
  by Jens Als-Nielsen and Des McMorrow
  John Wiley and Sons: ISBN 0471498580

- Elements of Slow Neutron Scattering
  by J. M. Carpenter and C-K Loong
  Cambridge University Press