(3/14/02)

On preparing for the midterm quiz on 3/21/02.

The quiz will be divided into two parts, one on cross sections and the theory of neutron interactions (SY) and the other on MCNP, neutron sources and detection (JCY). Denote them as Parts A and B.

The source materials for Part A consist of four sets of lecture notes.

 Chap III, 22.111 Lecture Notes

 Chap VII, 22.111 Lecture Notes

 Chap VI. 22.113 Lecture Notes, only those parts on the Scattering Amplitude and the
    Born Approximation which were discussed in the class lectures

 Chap. IX, 22.113 Lecture Notes, only parts of Secs. A, B, C and E which were
    discussed in the class lectures

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For Part A the Topics which you should know are:

1. The Microsocpic Cross Section σ --
        basic physical definition
        using σ to calculate the probability of a collision
2. Neutron-Proton Scattering --
        setting up $d\sigma / d\Omega$ in terms of $f(\theta)$
        introducing the s-wave phase shift δ_o

        what is meant by low-energy scattering?

        cross section in terms of the scattering length a

        what is the meaning of the sign of the scattering length a?

        finding δ_o for the n-p problem

        numerical value of calculated $\sigma(n,p)$ as compared to experiment

        how does one understand the importance of spin-dependent interaction?
3. Basic Kinematics of Elastic Neutron Scattering --
        momentum and energy conservation
        one-to-one relation between scattering angle and outgoing neutron energy
        elastic scattering in CMCS
4. Energy and Angular Distributions in Elastic Neutron Scattering --
        concept of differential cross sections $d\sigma / d\Omega$ and $d\sigma / dE$

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transformation properties of distribution functions

transforming $d\sigma / d\Omega$ between CMCS and LCS

energy distribution $F(E \rightarrow E')$ and underlying assumptions

5. Thermal Neutron Scattering --

what is the Fermi Approximation, is it valid for thermal neutron scattering, and
   why is it useful?

explain coherent and incoherent scattering
concept of double differential scattering cross section $d^2\sigma / d\Omega dE_f$

what is the dynamic structure factor and why is it important?

energy variation of σ in a liquid or crystalline moderator

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Following are some sample questions appropriate for Part A (meant to be illustrative only) --

1. Using a simple sketch, give a physical definition of the angular differential cross section $d\sigma / d\Omega$. How would you extend this definition to the double differential cross section $d^2\sigma / d\Omega dE_f$?

2. Given the microscopic cross section σ, find the probability of a neutron having one and only one collision while traveling a distance x.

3. What is the physical reason that thermal neutron scattering can be treated as low-energy scattering?

4. Give a simple argument showing that only the s-wave contribution is important in low-energy scattering.

5. If n-p scattering can be treated quite simply, what is the reason that the theory of thermal neutron scattering so much more complicated?

6. In a neutron diffraction experiment, what cross section, if any, is measured?

7. Which cross section is more useful for neutron diffraction, incoherent or coherent?

8. What is the difference between neutron and x-ray diffraction so far as the basic interaction with the sample is concerned?

9. Deriva a relation between the scattering angles in LCS and CMCS for neutron elastic scattering by a target nucleus at rest.

10. By examining the diagram of velocities in LCS and CMCS for elastic scattering by a target nucleus at rest, decide which of the following holds for the angular distribution in LCS, if the scattering is isotropic in CMCS: Isotropic, forward biased, or backward biased. What would be the result if the target nucleus is infinitely heavy?

11. What changes do you expect in $F(E' \rightarrow E)$ for elastic scattering at low energy by a target nucleus which is not at rest?

12. In the Born approximation for the scattering amplitude $f(\theta)$, where θ is the scattering angle, where does θ appear in the approximation?