Spin Echo Scattering Angle Measurement (SESAME) – *Quantum Computing with Neutrons*

Low Energy Neutron Source

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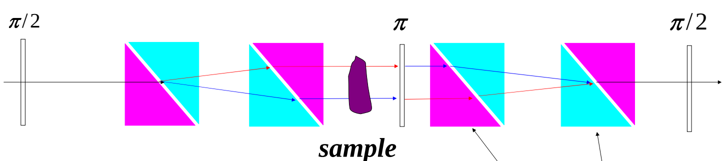
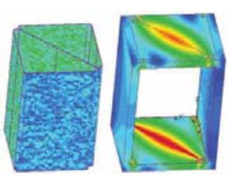
Neutron scattering is a signal-limited technique. Our goal is to make better use of the available neutrons by decoupling resolution and intensity using an interference technique. We plan to use the method to measure in-plane structure of surfaces and interfaces.

How does it work?

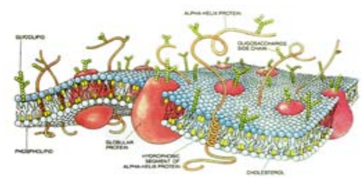
Magnetic fields are birefringent for neutrons – "up" and "down" spins have different refractive indices in a magnetic field.
Two pairs of triangular magnetic prisms introduce a phase difference between the "up" and "down" spin components of a neutron beam that is initially prepared in the entangled state (an eigenstate of Sx). The phase difference depends on the angle of incidence of the neutron on the triangular prisms. The prisms are solenoids energized by dc currents.

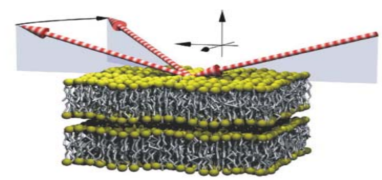




Finite element calculations (left) confirm that the magnetic field inside the prisms (right) is very uniform, as required

Scattering from a sample causes the angle of incidence of the neutrons on a second set of triangular prisms to be different from the angle of incidence on the first set of prisms. As a result, the phase difference between the "up" and "down" states introduced before the sample is not cancelled after the sample and the final beam polarization is a measure of the neutron scattering angle.





Potential application: study of the in-plane structure of membranes by neutron reflection

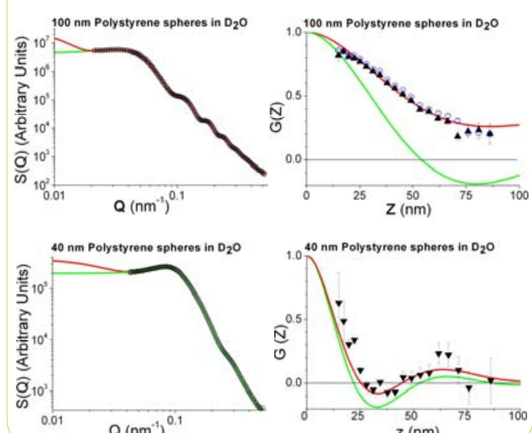
Experiment at LANSCE

SESAME apparatus installed on the polarized neutron reflectometer ASTERIX at the LANSCE pulsed spallation neutron source.

The equipment we have designed can be used equally well at pulsed and CW neutron sources, so it would be suitable for use either at SNS or HFIR.

Compare SESAME & SANS

SESAME measures a real-space correlation function – the Patterson function G(Z). To the right below are shown the Patterson functions measured on ASTERIX with polystyrene spheres of nominal diameter 100 nm and 40 nm. To the left is SANS data obtained at HFIR on the same samples. Two different extrapolations of the SANS data into the beam stop are shown. The G(Z) resulting from these extrapolations are shown on the right hand figures.



Summary

- **Spin echo scattering angle measurement (SESAME) has been successfully demonstrated using triangular magnetic solenoids**
- **Accurate results have been obtained for 40 nm and 100 nm polystyrene spheres in D_2O**
- **Results show that SESAME can measure scattering usually hidden from conventional SANS**

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