Spin Echo Small Angle Scattering on ASTERIX

Low Energy Neutron Source

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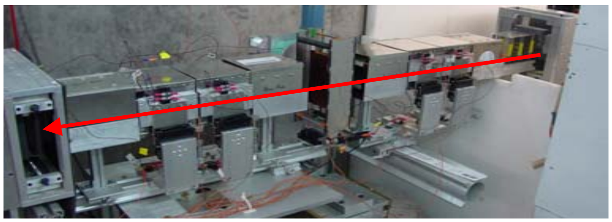
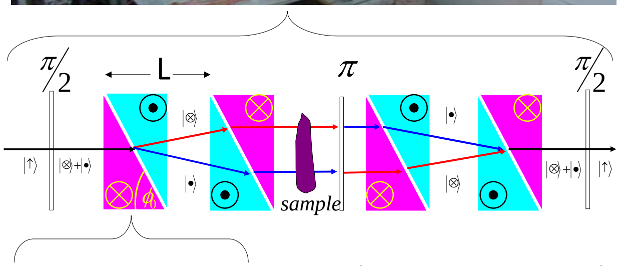
SESAME mounted on the ASTERIX Beamline at the Lujan Center (Los Alamos, NM).





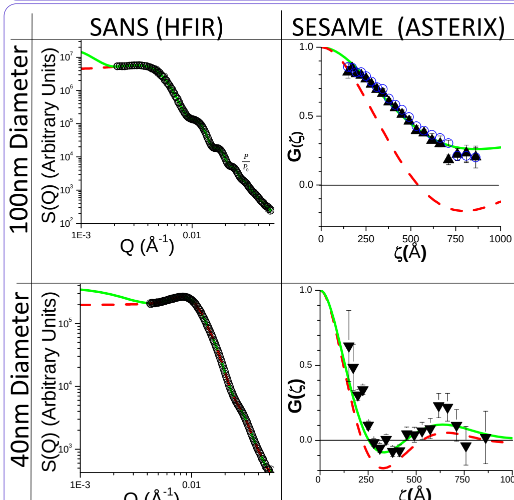
Partially Assembled Triangle Coils

Spin Echo Scattering Angle Measurement (SESAME) uses triangular solenoids to encode the neutron scattering angle into the polarization of the neutron beam. The magnetic fields split the two spin states of the beam based on their index of refraction. The incident angle is encoded into the phase difference between the two spin states. The spatial separation between the two states determines the Spin Echo Length (the length scale which can be probed). **As the spin echo length is dependent on neutron wavelength, the instrument is capable of simultaneously investigating a wide range of correlation lengths when used at a pulsed neutron source.**

Scattering changes the angle of incidence on the second set of solenoids. The scattered beam decodes at a different phase angle from its initial encoding, resulting in depolarization of the detected neutron beam. **Since the depolarization is dependent only on the scattering angle and not the incident angle, SESAME has no need to lose beam intensity through limiting the beam size or beam collimation.**

$$\frac{P}{P_0} = e^{G(\zeta)-G(0)} \qquad \zeta = c\lambda^2 BL\cot\phi_0 \qquad G(\zeta) = \frac{\lambda^2}{4\pi^2}\frac{1}{A}\int_{-\infty}^{\infty} dQ_y \int_{-\infty}^{\infty} dQ_z \frac{d\sigma}{d\Omega}(0,Q_y,Q_z)\cos(Q_y\zeta)$$

P=Final beam polarization; P_0=Initial beam polarization; ζ=Spin echo length; $G(\zeta)$=Generalized Patterson function; $c=1.476\times10^{14}\,T^{-1}m^{-2}$; λ=Neutron wavelength; B=Magnetic field strength within each triangular solenoid; L=Distance between triangle coils; ϕ_0=Solenoid angle of incidence; A = Sample area;



We examined two samples of polystyrene nanospheres on the ASTERIX beamline. The data from the graphs on the top row were taken with 100nm diameter spheres suspended in D_2O while the bottom row used spheres with 40nm diameters. The 100nm spheres were tested at 10.2% and 7.8% by mass concentrations while the 40nm sphere solution was 2.7% by mass

The data points in the left column were taken on a general purpose SANS machine at the HFIR using 12Å neutrons. On each set of SANS data, two different extrapolations into the beam stop region have been plotted.

The data points in the right column are the real space scattering (generalized Patterson functions) measured by SESAME. Also plotted are the Fourier transforms into real space of the SANS scattering data using the two small angle extrapolations plotted in the left hand column.

For both samples, the red, dashed line represents the expected scattering function assuming Percus-Yevick correlations between the nanospheres. For the 40nm sample, the green, solid line represents an arbitrary fitting function. For the 100nm spheres, the solid, green line is again the Percus-Yevick correlations, but with 1.4% by mass of the polystyrene spheres forming spherical aggregates with a diameter of 420nm. These aggregates are hidden from SANS by the beam stop, but accessible to SESAME, since it can differentiate between scattered and unscattered beam even when they overlap.

Conclusions

SESAME equipment can easily be added to existing beamlines.

SESAME results for 40nm spheres are equivalent to SANS.

For 100nm sphere samples, SESAME provides information hidden within the SANS beamstop.