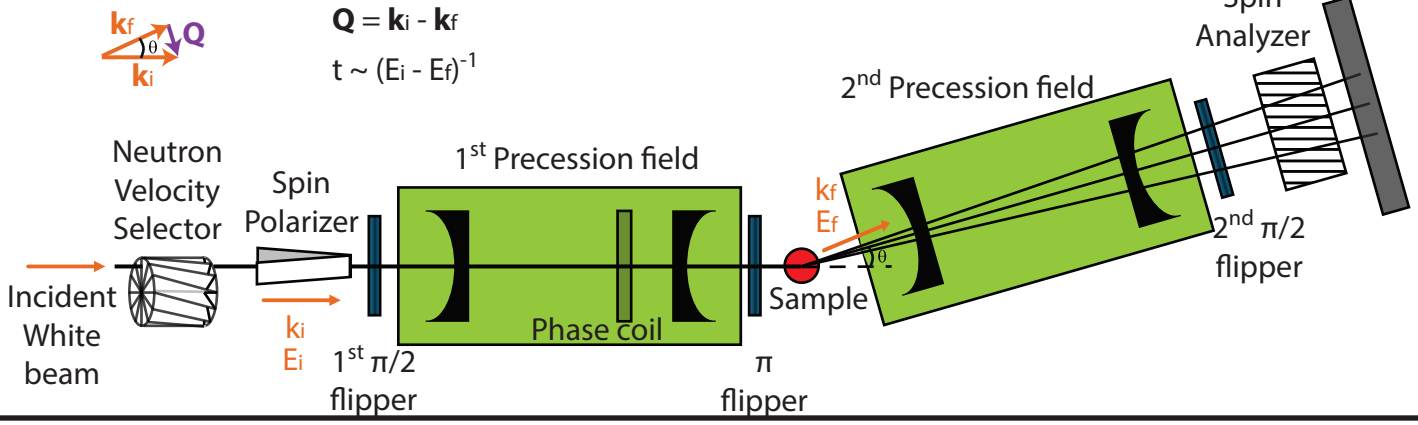
Online Card

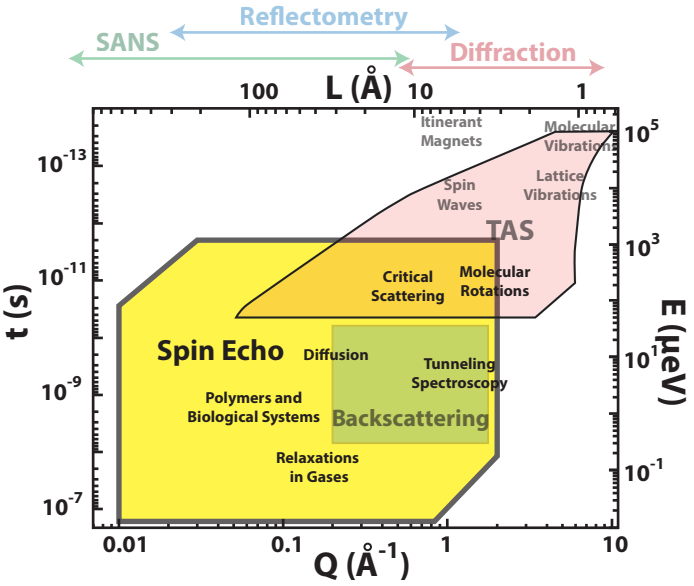
Neutron Spin Echo

CIRNS NSF CENTER FOR HIGH RESOLUTION NEUTRON SCATTERING

NIST CENTER FOR NEUTRON RESEARCH

Measure Intermediate Scattering Function: I(Q,t)





Operating Principles

1) Incident beam is coarsely monochromated and polarized vertically.

2) A horizontal field **B** precesses the neutron spin (starting at φ=0).

3) At the sample the neutron has an accumulated a total phase φ_1.

4) Scattering at the sample changes k_i and E_i to k_f and E_f.

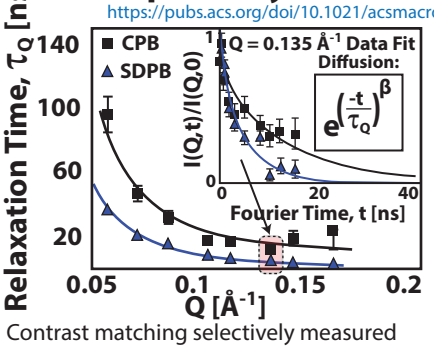
5) The neutron spin then reverses its precession in a 2nd field, which 'unwinds' the accumulated phase.
   Elastic Scattering: initial phase restored (φ=0)
   Inelastic Scattering: a finite phase φ(Ei - Ef) persists.

6) A spin analyzer transmits neutrons with probability <cos φ>.

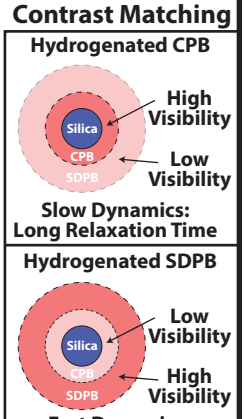
7) A detector after the spin analyzer measures the neutron polarization, which is proportional to the normalized intermediate scattering function I(Q,t)/I(Q,0).

Example: Polymer Chain Dynamics

https://pubs.acs.org/doi/10.1021/acsmacrolett.8b00223

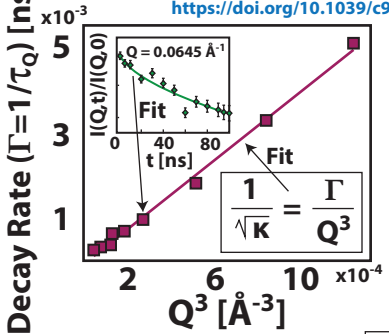


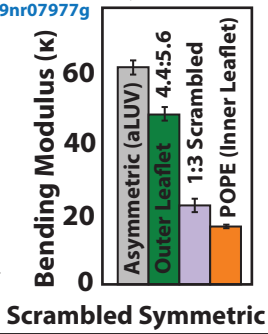
Contrast matching selectively measured the relaxation of the concentrated and semidilute polymer brush regions (CPB and SDPB) of grafted SiO_2 nanoparticles. The CPB region relaxed slower than the SDPB region due to increased chain confinement.



Example: Lipid Membrane Dynamics

https://doi.org/10.1039/c9nr07977g

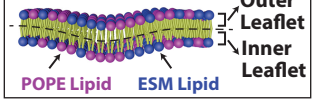




Asymmetric lipid vesicles (ALUV) show slower membrane undulation dynamics, indicating more rigid membranes compared to their symmetric counterparts.

Scrambled Symmetric

same ESM:POPE ratio on leaflets



Instrument Webpage

Neutron Spin Echo (NSE)

Instrument Paper: https://www.nist.gov/ncnr/chrns-nse-neutron-spin-echo-spectrometer

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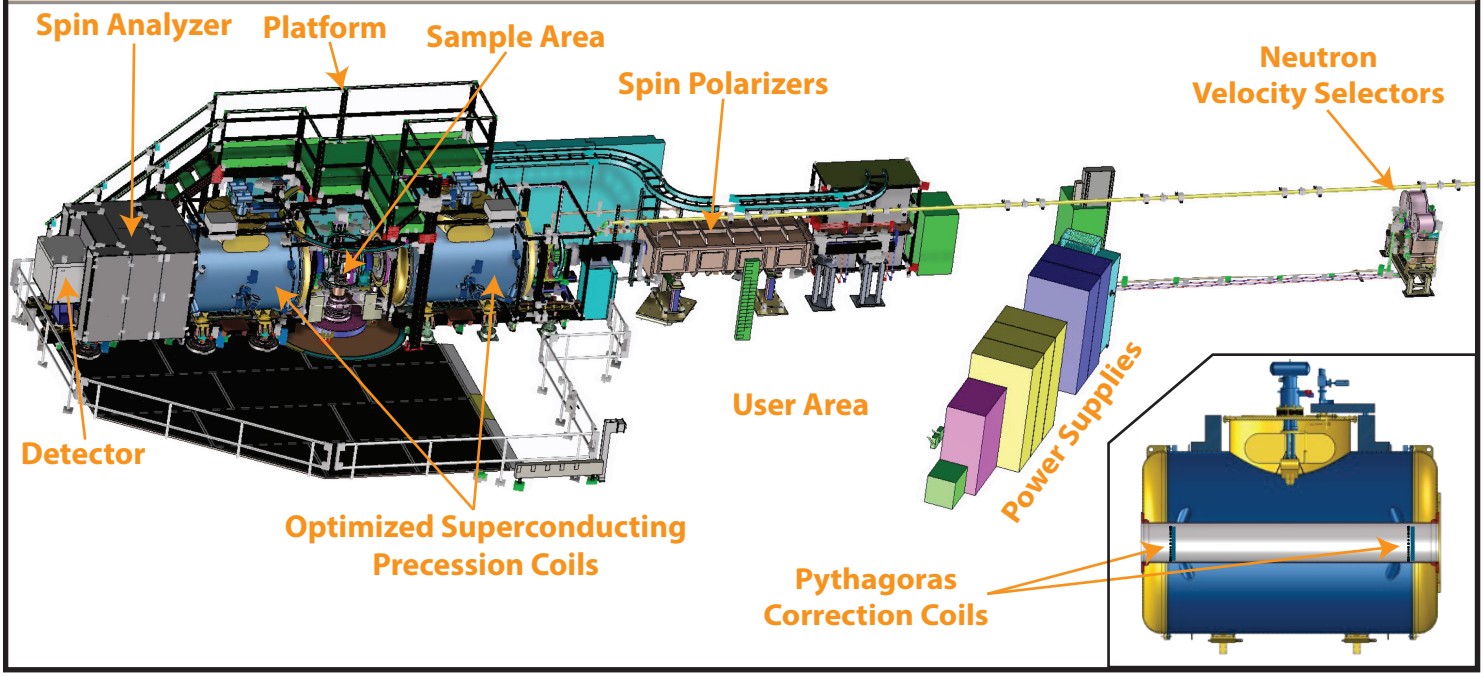
The upgraded Neutron Spin Echo (NSE) spectrometer uses Larmor precession of the neutrons' magnetic moment as an internal clock to measure the energy exchanged with the sample upon scattering. With data collection in the time domain rather than in the frequency domain, this unique approach provides tight energy resolution of ≈ 0.01 μeV over a wide range of incident wavelengths for Fourier times as long as 700 ns. NSE is thus optimal for investigations of slow relaxational processes in biomembranes, polymers, colloids, supercooled liquids, and frustrated magnets.



Liquid sample mount

System	Range
1 Position	15 ˚C to 125 ˚C
3 Position	-20 ˚C to 75 ˚C

Top loading Closed Cycle Refrigerator

System	Range
Low Temperature stick	4 K to 325 K
High Temperature stick	50 K to 700 K

Bottom loading Closed Cycle Refrigerator

System	Range
Low T	2.5 K to 325 K
Mid T	25 K to 420 K
High T	15 K to 325 K

Liquid Helium Cryostats

System	Range
ILL orange cryostat (50 mm)	1.5 K to 300 K

Monochromator

- **Velocity selector 1:** wavelength from 4.5 Å to 11 Å; resolution 10% to 20%
- **Velocity selector 2:** wavelength from 10 Å and longer; resolution 15%

Spin Polarizer

- **Single V cavity:** for wavelength longer than 10 Å
- **Double V cavity:** for wavelength from 4.5 Å to 11 Å

Spin Analyzer

- **FeSi supermirror array:** 300 mm x 300 mm coverage

Detector Options

- **^{3}He tube detector:** 4 x 8 pack of 8 mm tube x 300 mm
- **^{3}He 2D ORDELA detector:** 300 mm x 300 mm area

Operational Range (TBC)

- **Wavelength range:** 4.5 Å to 20 Å
- **Accessible scattering angle range:** 2.5˚ to 95˚
- **Accessible magnetic field integral range:** 0 to 1.2 Tm

Dynamic Range (TBC)

- **λ = 5 Å:** 0.07 Å^{-1} ≤ Q ≤ 1.8 Å^{-1}, 3 ps ≤ t ≤ 30 ns
- **λ = 8 Å:** 0.05 Å^{-1} ≤ Q ≤ 1.1 Å^{-1}, 10 ps ≤ t ≤ 100 ns
- **λ = 11 Å:** 0.04 Å^{-1} ≤ Q ≤ 0.8 Å^{-1}, 50 ps ≤ t ≤ 300 ns
- **λ = 15 Å:** 0.03 Å^{-1} ≤ Q ≤ 0.6 Å^{-1}, 150 ps ≤ t ≤ 700 ns