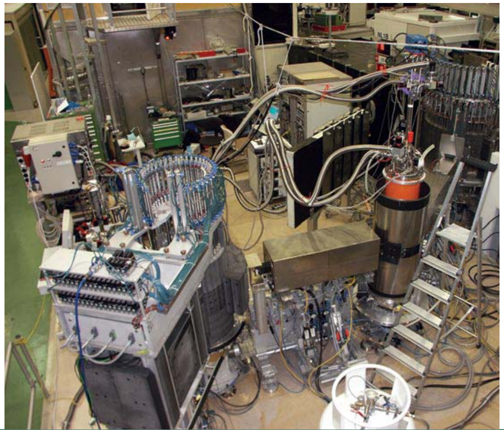


V2-II | Triple-Axis Spectrometer for Cold Neutrons (FLEX) – NRSE-Option

FLEX offers the possibility to combine triple-axis spectroscopy with high resolution spin-echo spectroscopy. The Neutron Resonance Spin-Echo technique (NRSE) is based on RF spin flippers replacing the Larmor precession solenoids used in conventional spin-echo spectrometers. This instrument is designed for the application of the 'tilted field' spin-echo focusing technique, which allows for the measurement of linewidths of dispersive excitations at an energy resolution in the order of μeV.

Instrument description

For the NRSE option on FLEX a polarizer/analyzer and two sets of RF-coils are inserted between monochromator and sample and between sample and energy analyzer. The neutron flight paths between the RF-coils are screened by a mu-metal shielding. At the sample position a vertical tube which is divided into two parts to allow for free passage of the incoming and scattered neutrons reduces the residual field to less than 5 mG. The RF-coils can be operated in either non-bootstrap (4π-) or bootstrap (8 π-)-mode to match specific resolution demands.

The main components of combined triple-axis- and spin-echo-instrument can be seen on the photograph. Inside the open boxes (closed during the measurement) the tilted RF coils are also visible. The maximum beam cross section is restricted to 30 x 30 mm² (at 45° tilt angle) by the coils which will be enlarged to 35 x 50mm² with a set of new coils in the near future. The transmission polarizers restrict the minimum available wavelength with polarized neutrons to 3.7 Å. As a second order filter either the tuneable PG filter or the Be-filter can be used in the incident beam.

The high flexibility in tilt angles without the need of field corrective elements allows for high resolution elastic measurements without restricting the divergence of the incoming beam. Depending on the relative orientation of the fields the measurement is sensitive to either a spread in d-spacings or sample mosaic. The resolution does not depend on the scattering angle. Due to the fact that in the Larmor diffraction mode all coil faces have to be parallel to each other not all Bragg peaks can be accessed although some flexibility is given by the choice of the incoming wavelength (see table for the restrictions in scattering angle).

Applications

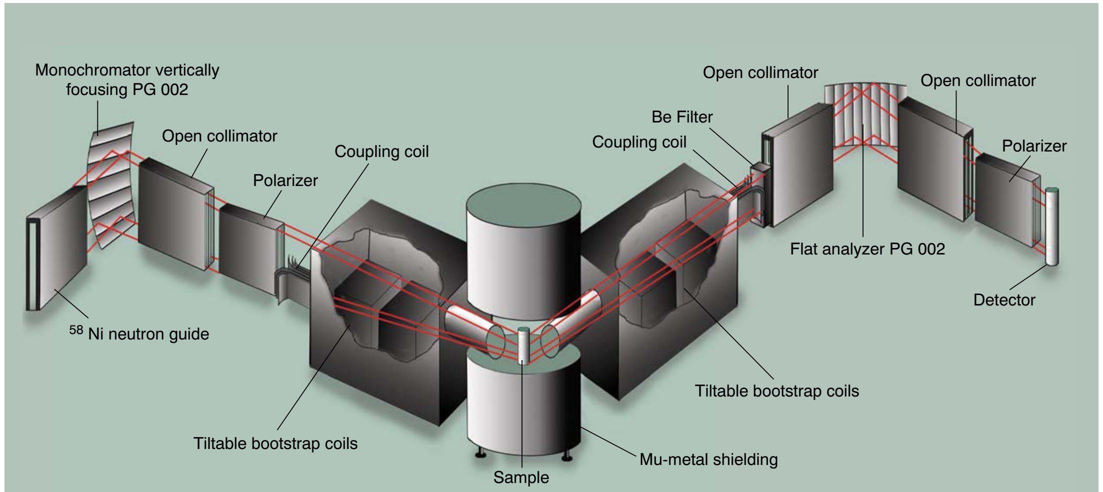
- linewidths of low-energy dispersive excitations in non-magnetic and antiferromagnetic samples
- quasi-elastic linewidths
- high-resolution elastic scattering (Larmor diffraction) with single crystal and powder samples

References

Habicht, K. ; Golub, R. ; Mezei, F. ; Keimer, B. ; Keller, T.:
Temperature-dependent phonon lifetimes in lead investigated with neutron-resonance spin-echo spectroscopy
Physical Review B 69 (2004), 104301

Fig. 1+2: Temperature-dependent phonon lifetimes in lead investigated with neutron-resonance spin-echo spectroscopy.

Results of experiments performed at V2/FLEX using the neutron-resonance spin-echo option. The linewidths of transverse-acoustic phonon modes in the low-q limit along the high-symmetry directions have been investigated at temperatures between 5-300 K (top: phonons along the [x00] direction). The linewidth data has been corrected for sample mosaicity and curvature of the dispersion surface. Observed linewidths are significantly lower than predicted by a theoretical model of anharmonic lattice dynamics based on a force-constant parametrization of the interatomic potential. In the high-symmetry directions the q dependence of the linewidth is found to be linear (Fig. 2)



Instrument Data

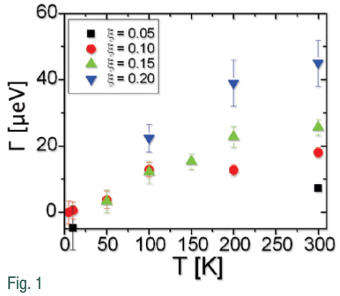


Fig. 1

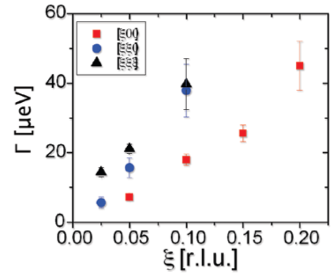


Fig. 2

Neutron guide	NL 1B with beam cross-section 125 mm (height) x 30 mm (width) and a radius of curvature of 3000 m
Monochromator	Pyrolythic graphite (002), with variable vertical curvature
- angular range	$67° < 2\theta_M < 150°$
- wavelength range	3.7 Å < θ_M < 6.5 Å (2.5 Å < θ_M < 6.5 Å in near future)
- energy range	6 meV < E_M < 27 meV
Range of scattering angle at sample table	
- inelastic mode	$-110° < 2\theta_S < 110°$ (with configurational restrictions)
- elastic (Larmor diffraction) mode	$-110° < 2\theta_S < 90°$ or $90° < 2\theta_S < 110°$
Analyzer	Pyrolythic graphite (002), uncurved
Range of scattering angle at analyzer	$-115° < 2\theta_A < 115°$
Effective collimation	40', 40', 40'
Polarizer and analyzer	Supermirror on silicon substrate in transmission
Filter	Be-filter at k_i or tuneable pyrolythic graphite
Flux at sample	3 x 10⁵ n /cm² s at 3.7 Å
Maximum effective spin echo field	1000 Gauß
Spin-echo time range at 3.7 Å	10 ps - 600 ps
Δd/d resolution in diffraction mode at 3.7 Å	3 x 10⁻⁴ (FWHM)
Instrument responsible	K. Habicht, habicht@hmi.de