High Resolution Inelastic Spectrometer

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1 Introduction

A high resolution inelastic spectrometer is at the stage of detailed design prior to installation on the SNS viewing the 20K moderator. It is the time-of-flight analogue of the backscattering spectrometer IN10 at ILL, Grenoble. By changing the neutron energy selector/analyser combination resolutions of $\sim$ 1 μeV and $\sim$ 13 μeV can be selected. The incident energy window is wider than that obtainable on IN10 and can be continuously extended by modulating the phase of the neutron energy band selector thus permitting inelastic measurements to be carried out with high resolution at energy transfers previously unattainable.

2 Scientific Background

The availability of a spectrometer which can measure energy transfers $\sim$ 3 meV with high resolutions will greatly extend the science carried out at present. It is expected that the study of diffusive motions in aqueous solutions, metal hydrides, superionic conductors, liquid and molecular crystals, intercalated compounds, and layered minerals will benefit from the ability to study the precise shape of the quasielastic peak out to higher energy transfers and, by changing the resolution during an experiment, to make precise measurements of the elastic incoherent structure factor. This latter point is particularly important when it is required to study the sample in an accurately known environment (temperature, pressure, concentration, humidity for example). At the present time such measurements in general require separate experiments on different spectrometers.

The measurement of tunnelling processes in molecular systems and the study of hyperfine splittings are fields which will benefit from the wider inelastic capabilities afforded by the the spectrometer. The separation and assignment of nearly degenerate crystal field levels should also be facilitated.

3 Instrument Description

A schematic diagram of the spectrometer is shown in the figure. It operates in two modes both employing the same principle of mechanically selecting, close to the moderator, a band of neutron energies ΔE having a time width $\delta t(E)$ and allowing this band to disperse over a 40 metre drift distance along a neutron guide to provide the required incident energy resolution within the constraints of the frame overlap condition. Neutrons scattered from the sample whose energy is changed by an interaction with the sample to exactly the analyser energy ($\sim$ 2 meV in both cases) are detected after backscattering from the crystal analyser system. Neutrons scattered directly into the detectors are discriminated against by the use of an asynchronous beam modulation chopper close to the analyser section.

By the use of a disc chopper as the neutron energy selector and graphite analysers a resolution $\sim$ 13 μeV is attainable over a window of $\sim$ 1 meV. Changing to the high resolution mode a fast Fermi chopper located 4.4 m from the moderator reduces the intrinsic time burst of the SNS pulse and in combination with a set of silicon analysers will provide a resolution $\sim$ 1 μeV within a window of $\sim$ 100 μeV. The intensity at the sample position is predicted to be $\sim 3 \times 10^4$ n cm^{-2} s^{-1} for the high resolution option and $\sim 5 \times 10^5$ n cm^{-2} s^{-1} for the low resolution option. A fuller list of instrument performance figures is given in Table 1.

In both modes it is possible to offset the phase of the first band selector with respect to the neutron pulse such that the window is centred around a discrete energy transfer to study a particular region more closely. It is also possible to modulate the phase of this chopper, for example sinusoidally, to cover a much wider range of energy transfers, possibly beyond 3 meV, in one measurement.

The neutron detector will comprise a position sensitive scintillator detector with $\sim$ 1500 elements set on a spherical surface precisely and permanently positioned in backscattering geometry with respect to both analyser banks (the graphite analysers being retractable). The centres of curvature of both sets of analysers and the detector will coincide at the sample position.

Table 1

Instrumental Parameter		Option	
		C(002)	Si(111)
Energy Resolution		13 μeV	1.2 μeV
Energy Window		960 μeV	100 μeV
Final Energy		2.07 meV	1.82 meV
Intensity at Sample		3×10^4 cm^{-2} s^{-1}	5×10^5 cm^{-2} s^{-1}
Scattering Angles		15^o-165^o	5^o-165^o
Q Range		0.25 Å^{-1} - 1.86 Å^{-1}	0.09 Å^{-1} - 1.98 Å^{-1}
Q Resolution at	15^o	5.7%	5.7%
	90^o	0.86%	0.75%
	165^o	0.61%	0.11%
δQ at	15^o	0.014 Å^{-1}	0.015 Å^{-1}
	90^o	0.011 Å^{-1}	0.011 Å^{-1}
	165^o	0.011 Å^{-1}	0.002 Å^{-1}
Solid Angle Detected		0.22 ster	0.85 ster

Quasielastic Scattering Spectrometer