High Energy Inelastic Spectrometer

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1 Scientific Background

A spectrometer is proposed than can be used for inelastic neutron scattering experiments at high energy transfers, $\hbar\omega$, and at low momentum transfers $\hbar Q$, which is an important requirement in several areas of science.

(a) In Liquids and gaseous samples, measurements of the high frequency molecular vibrations require small Q vectors to minimise diffusional broadening of the features of the spectrum which increase as Q^2.

(b) In solids, the study of high energy internal vibrational modes require small Q vectors to reduce the effect of multi-excitations of low energy modes. The effect can be to broaden each mode by an amount which increases very rapidly with Q.

(c) The observation of high frequency magnetic excitations requires small Q vectors because the magnetic scattering is modulated by the square of the form factor F(Q) describing the spatial distribution of the spin density around the magnetic ions.

2 In addition the instrument will have the capability of making measurements of high momentum transfer $\hbar Q$, an important region for experiments on quantum liquids for example.

3 Instrument Description

The instrument is designed to measure energy transfers $\hbar\omega$ in the range 100 - 500 meV with momentum transfers $\hbar Q < 6$ Å^{-1} but it can be used outside this range. Figure 1 shows the layout. Incident energies from 200 - 1000 meV are used and selected by a fast neutron chopper placed 10 m from an ambient temperature moderator. The chopper operating at 600 Hz (12 times the SNS frequency) is accurately phased to the SNS pulse to ± ½ μ us and a range of incident energies chosen by varying the chopper phasing. In order to cover the whole energy range a set of four choppers will be required. Neutrons selected by the chopper fall on the sample placed 2 m downstream. This distance, containing collimation, is needed to ensure that low angle counters do not have a direct view of the chopper or chopper tank. Neutrons scattered from the sample are detected by annular Li-glass scintillator detectors at 4 m (3^{o} - 7^{o}) and 2 m (8^{o} - 30^{o}) from the sample. In addition to the horizontal plane there is a set of scintillator detectors from 3^{o}-30^{o} in $\frac{1}{2}^{o}$steps ∿ 5 cm high for vector Q experiments. The main beam passes through the centre of the counter array to a beam stop 4 m downstream. Scatter from windows and air in the main beam is eliminated by evacuating the sample chamber and detector box which are connected by a vacuum gate valve. Single samples can be mounted in the vacuum at temperatures between 77K and 1200K. A 4 position sample changer can be fitted operating down to 77K. An insert with thin windows fitted to the sample box enable liquid helium crystats to be placed in the beam. The cryostat is supported from below by an automated goniometer. A small bank of counters is also placed at 4 metres from the sample at a scattering angle of 140^{o} for measurements at large values of momentum transfer. In addition space is available for this bank to be extended in the future to a scattering angle of 70^{o}. The high angle banks will be filled with helium gas. The neutrons detected are time-sorted into 2000 time channels whose widths can be chosen to be between ½ μs - 10 μs.

4 Instrument Performance

The energy resolution has been estimated assuming the instrument views the moderator normally. There is an advantage in viewing the moderator at an angle due to time focussing, the optimum angle being between 20^{o} and 30^{o}. At angles greater than 30^{o}, the moderator flux is reduced in value. Figure 2 shows the energy resolution plotted against energy transfer for two values of incident energy, for a scattering angle of 3^{o} and a counter bank at 4 m, together with the corresponding momentum transfers. Figure 3 shows similar curves for a 2 m bank. The low angle counter banks 3^{o} - 30^{o} give momentum transfers of ∿ 2 Å^{-1} - 10 Å^{-1} and the 140 bank ∿ 34 Å^{-1}. The counter bank for vector Q experiments subtending an angle of $\frac{1}{2}^{o}$ at the sample gives $\Delta Q \sim 0.1$ Å^{-1}. The intensity at the sample is estimated to be 1×10^{4} cm^{-2} s^{-1} at 1.0 eV.

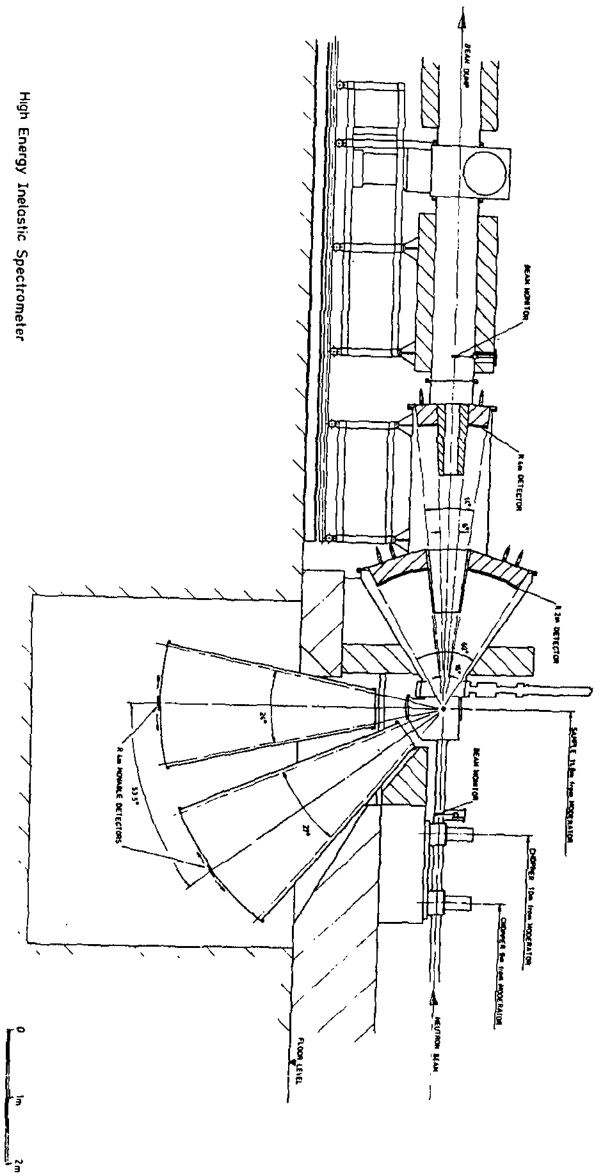

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FIG 1

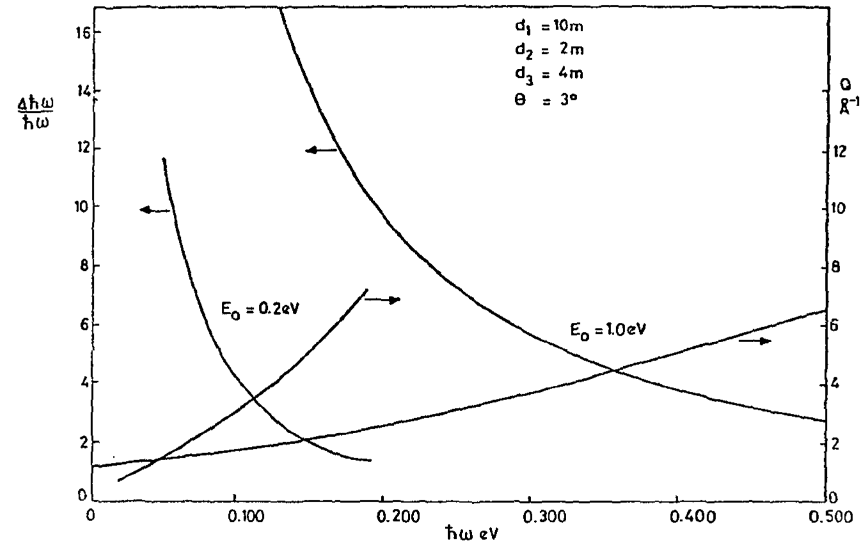

FIG 2

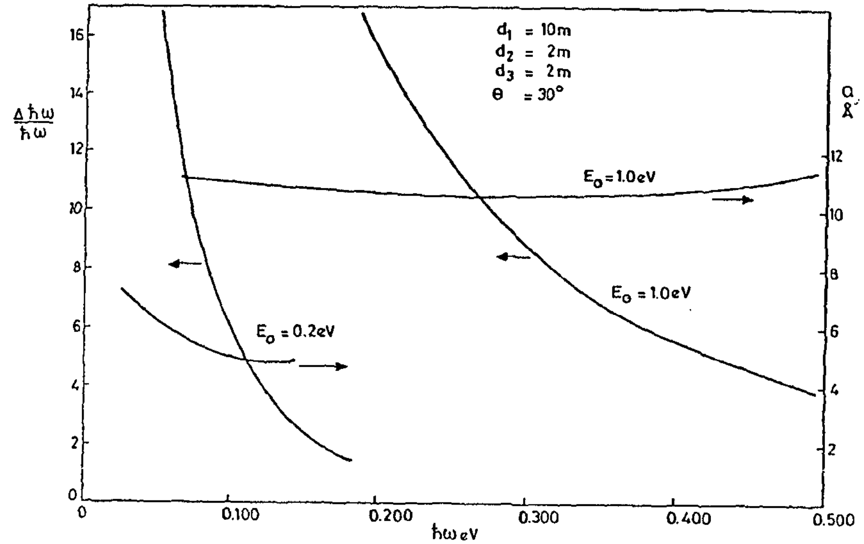

FIG 3