THE INELASTIC ROTOR SPECTROMETER AT THE HARWELL LINAC

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1. INSTRUMENT DESCRIPTION

The Harwell Linac has been operating routinely for approximately 6 months at 25 Kw power and 75 Hz into a tantalum target. During this period a number of test experiments has been carried out and a period set aside for university user experiments.

The instrument viewed a water moderator in slab geometry at 25° to the normal. The moderator was 4.4 cm thick with gadolinium poisoning 13 mm below the surface. No decoupler was present. The measured coupling efficiency is 5×10^{-4} n(1 eV)/n_f/ster.

The spectrometer is designed to measure energy transfers from 50 meV to 400 meV covering a range of Q values from 1-15 $Å^{-1}$. Particular emphasis has been placed on the low Q counter banks where measurements at low Q reduce multiphonon contributions in vibrational spectra, diffusional broadening in liquids and allow measurements to be made on magnetic excitations(1). The spectrometer consists of a Nimonic rotor, rotating at 600 Hz, accurately phased to the linac with a jitter of less than $\pm \frac{1}{2}$ μs, placed at 6.4 metres from the moderator. Incident energy (E_o) selection is made by varying the phase of the rotor with respect to the linac. E_o can be varied from 150 meV to 500 meV. The selected neutrons are allowed to fall on the sample placed 1 metre downstream in an evacuated chamber. Sample temperature can be controlled from 20K to room temperature. Low angle counter banks are placed between 4°-11° either side of the main beam at 2.5 metres. In addition, counter banks are placed every 10° between 24°-94° at 1.62 metres. The counters are 1" diameter He^3 10 atmosphere and 4 atmosphere respectively. The region of (Q,ω) space covered for two values of E_o is shown in Figure 1 together with that covered by a beryllium filter spectrometer operating at these energy transfers. The energy resolution is estimated to be 7 meV at an energy transfer of 150 meV (4.7%). The intensity at the sample was measured using vanadium scattering to be 1100 n/s over 2" x 1" beam at 450 meV E_o.

2. EXPERIMENTAL RESULTS

Figure 2 shows the measured spectra for a sample of sodium bifluoride $NaHF_2$. The sample was ∿ 13% scatterer 3 mm thick inclined at 45° to the beam and kept at 90K. $NaHF_2$ in the pure salt form has been investigated before with neutrons but only at high Q values and relatively poor energy resolution using the beryllium filter technique (2). The bifluoride ion has a sharp bending mode ν_2 at 156 meV and an antisymmetric stretch ν_3 at ∿ 177 meV. The two modes are separated in the pure salt by IR measurement (3) but are both broad due to interactions with near ions. In a dilute sample of HF_2 ions in KCl the modes are seen as extremely narrow peaks in the IR spectrum. The modes have not been separated before in a neutron scattering experiment from the pure salt. In Figure 2 the two modes as seen by the low Q counter bank of the IRS are seen to be clearly separated (the ordinate, S, is proportional to $S(Q,\omega)$); the insert shows the comparable spectrum measured on the beryllium filter spectrometer IN1 at ILL. In addition, in collaboration with Durham Univer-sity[4], the sodium bifluoride was run at a higher incident energy E_0 = 450 meV in order to collect data on the second harmonic at ∿ 300 meV. In a run of length 78 hours, data were collected over a wide Q range. Figures 3 and 4 show the raw data from the low angle (7°) counter and the 24° counter. Under these conditions the resolution is not good enough to separate the bend and stretch modes.

In a collaboration with the Universities of Munster and Birmingham (5) data were taken on samples of vanadium, and vanadium titanium, hydrides. With little multiphonon broadening of the optical mode, data from the high angle counter banks can be summed with little or no loss of resolution. Figures 5 and 6 show reduced data ($S(Q,\omega)$ against $\hbar\omega$) for the twosamples with the optical mode clearly split.

3. CONCLUSION

All indications are that the energy resolution is as predicted and is certainly twice as good as that of any other spectrometer presently available to the UK users at these energy transfers. Backgrounds on the high angle banks 24°-94° are excellent but at the low angles are too high at present for anything but hydrogenous samples. Tests have shown that much of this background comes from the main beam in the area of the collimation between the chopper and the sample, and steps are being taken to improve this area.

References

(1) Boland B C, Mildner D F R, Stirling G C, Bunce L J, Sinclair R N, Windsor C G, Nuclear Instruments and Methods 154 (1978) 349.

(2) Waddington T C, Howard J, Brierley K P and Tomkinson J, J Chem Phys 64 (1982) 193.

(3) Salthouse J A and Waddington T C, J Chem Phys 48 (1968) 5274.

(4) Howard J, Tomkinson J, Boland B C, to be published.

(5) Severin H, Wilson S K P, Wicke E, Ross D K, Carlile C J, to be published.

IRS Instrument Parameters

Moderator	5 cm thick water - Cd poisoned Slab geometry Viewed at 25^{o} to normal Area $\sim$ 170 cm^2 No decoupler
Chopper	At 6.4 metres 12 slot Nimonic operating at 600 Hz Beam size 2" x 1" Peak transmission at 300 meV Phased to better than $\pm$ ½ μs
Sample	At 7.4 metres In evacuated chamber Room temperature to 20^{o}K Displex type cryostats
Detector	Low angle 4^{o}-11^{o} either side of main beam 2 x 12 10 atmosphere He^3 counters at 2.5 metres 8 banks 24^{o}-94^{o} each 2 x 18" 4 atmosphere He^3 at 1.6 metres
T.O.F.	1024 channels channel width 1 μs variable start delay
Flux on sample	$\sim$ 4 x 10^3 n/s at full power at E_o = 450 meV.

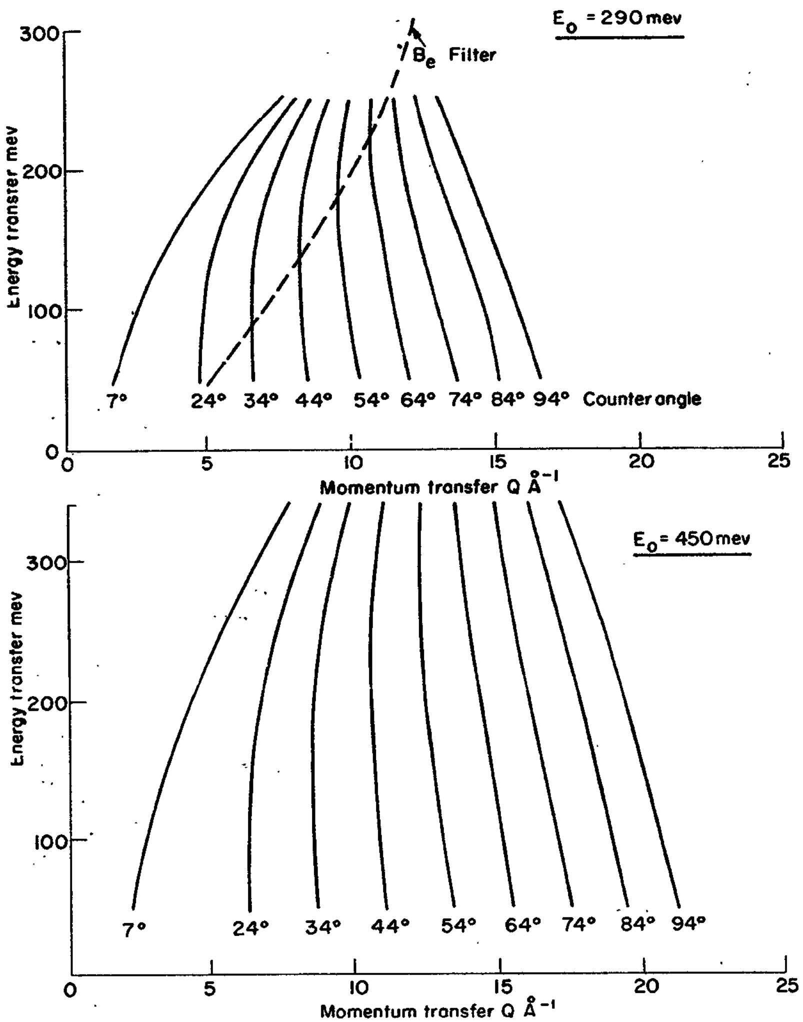


Fig. 1. Inelastic rotor spectrometer.

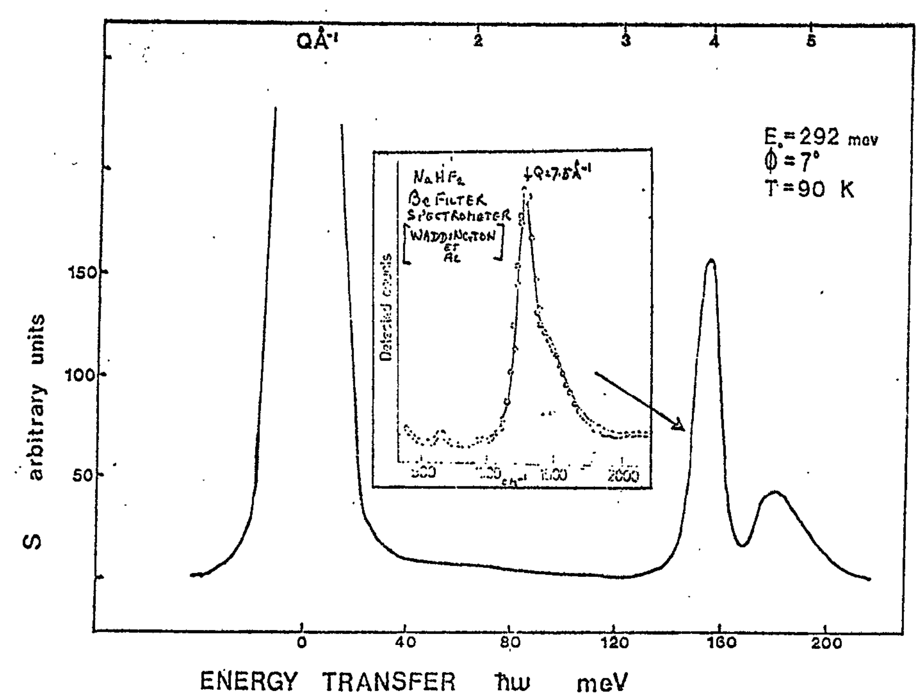


Fig. 2

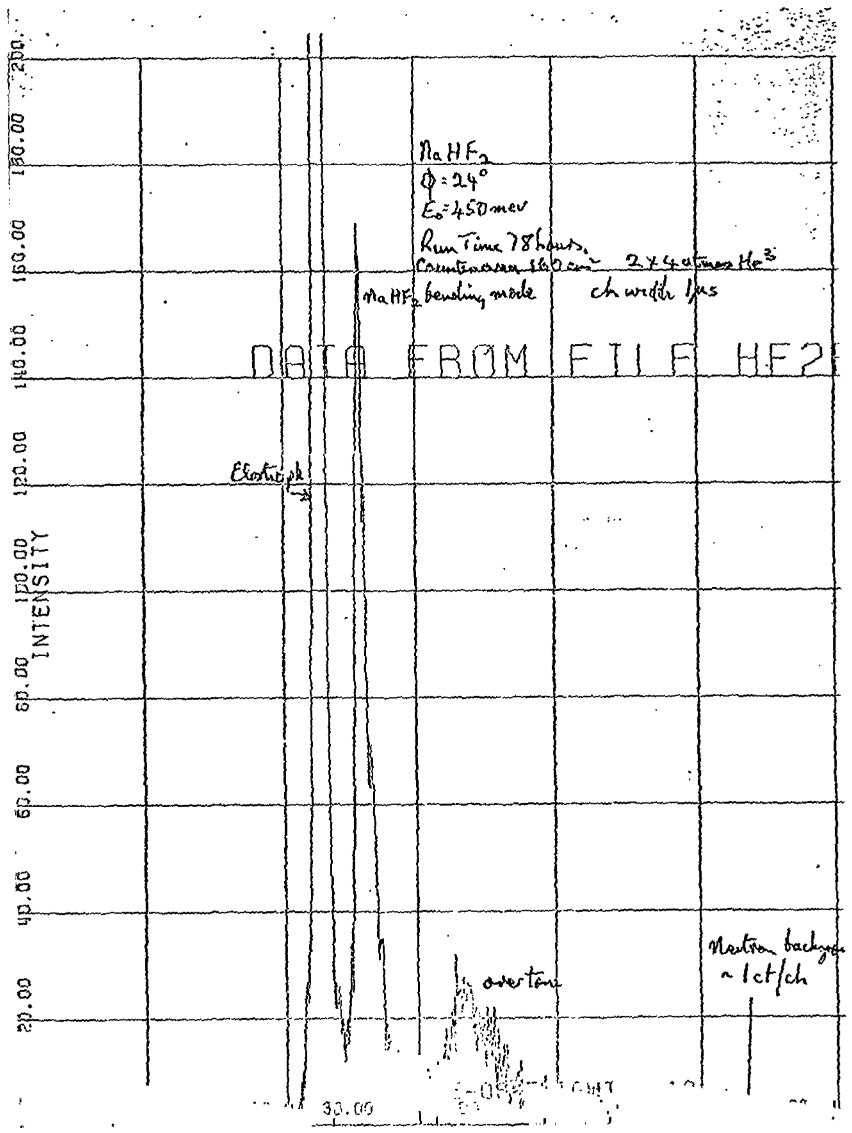

INTENSITY
DATA FROM FILE HE2
$NaHF_2$
φ = 24°
E_0 = 450 mev
Run Time 78 hours
$NaHF_2$ bending mode
ch width 1μs
Elastic pk
overtone
Neutron background
~1 ct/ch

Fig. 3

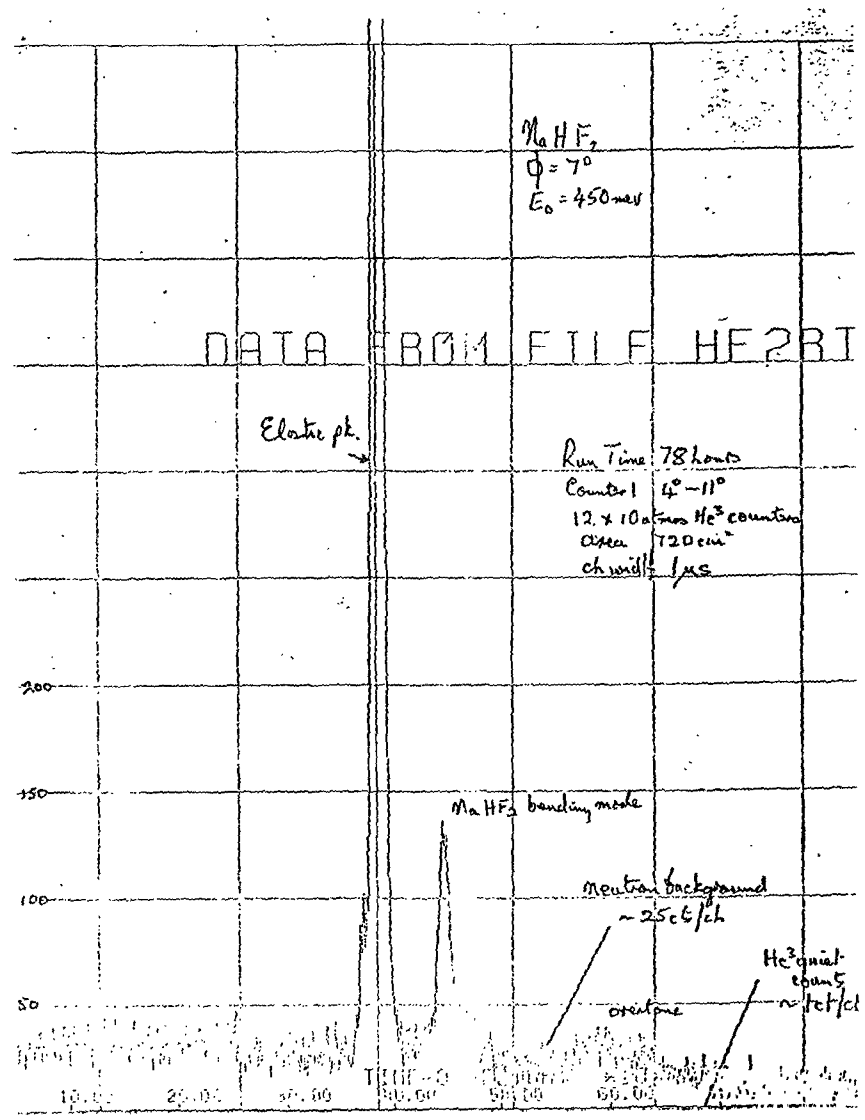
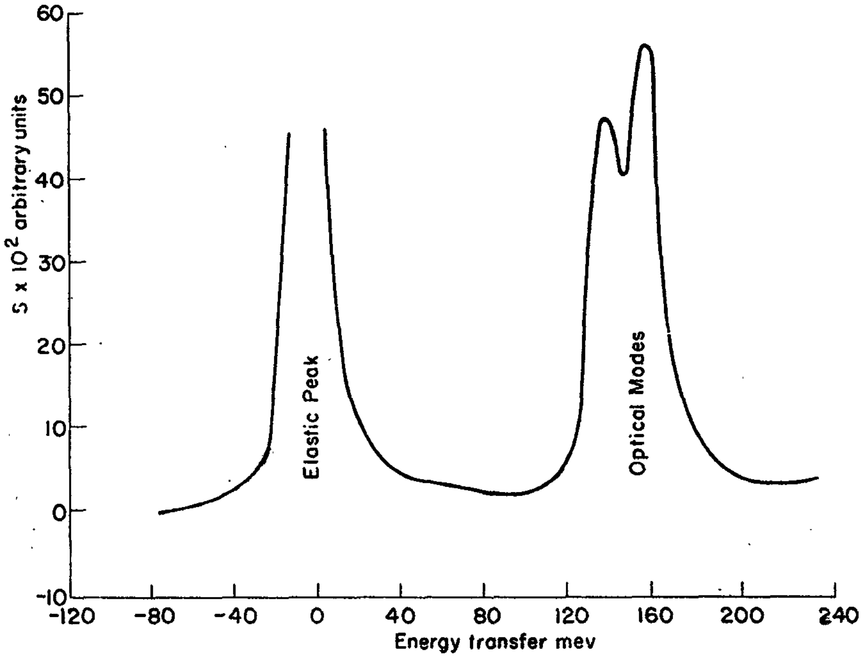

DATA FROM FILE HE2RT
$NaHF_2$
φ = 7°
E_0 = 450 mev
Elastic pk.
Run Time 78 hours
ch width 1μs
$NaHF_2$ bending mode
Neutron background
~25 ct/ch
overtone

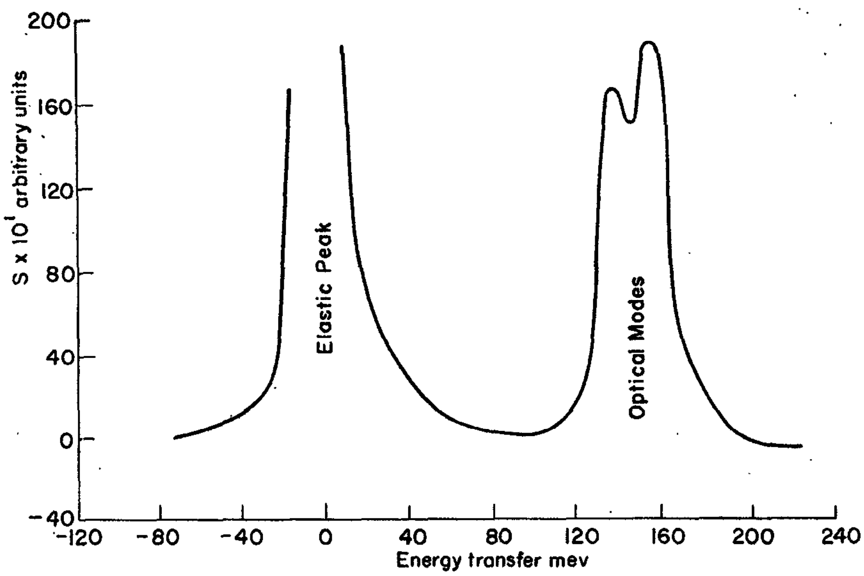
Fig. 4



Vanadium Hydride

Run time — 48 hours

Fig. 5



Vanadium Titanium Hydride

Run time — 48 hours

Fig. 6

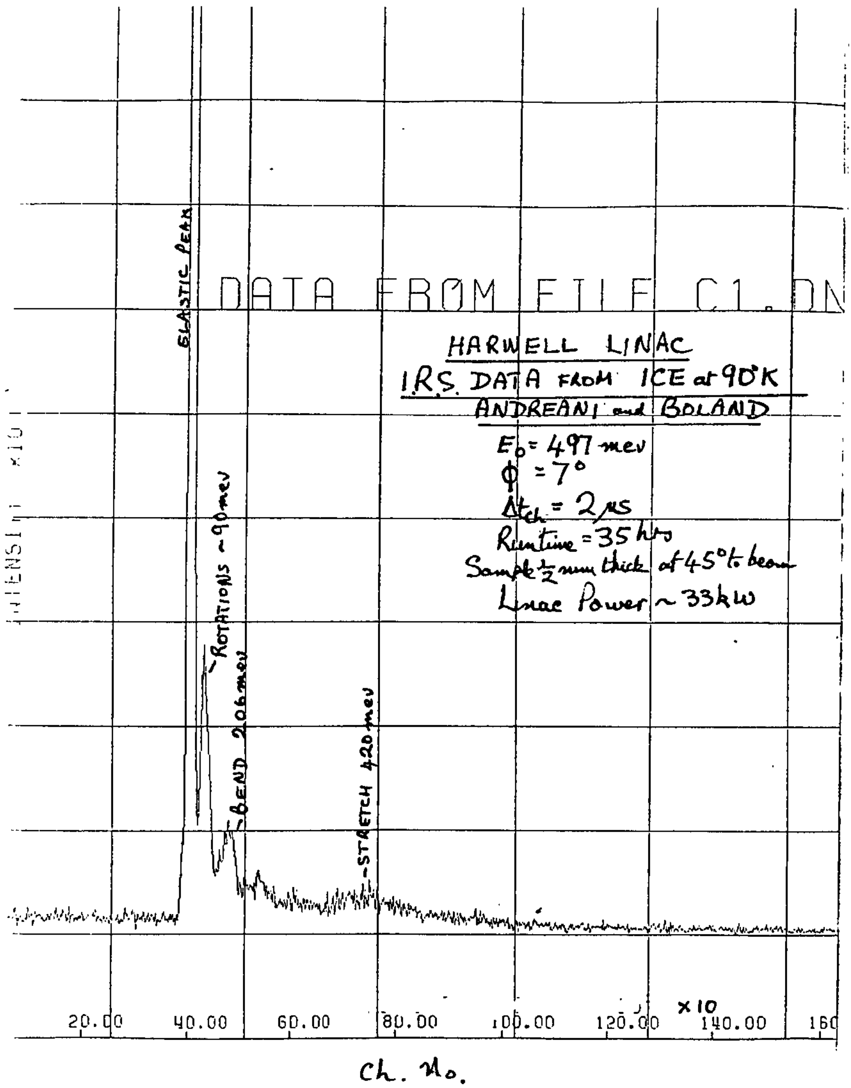

DATA FROM FILE C1.DN
HARWELL LINAC
IRS DATA FROM ICE at 90°K
ANDREANI and BOLAND
E_0 = 497 mev
ϕ = 7°
Δt_{ch} = 2 μs
Runtime = 35 hrs
Sample ½ mm thick at 45° to beam
Linac Power ~ 33kW
ELASTIC PEAK
ROTATIONS ~ 90mev
BEND 206mev
STRETCH 420mev
INTENSITY
20.00
40.00
60.00
80.00
100.00
120.00
140.00
×10
Ch. No.

Fig. 7

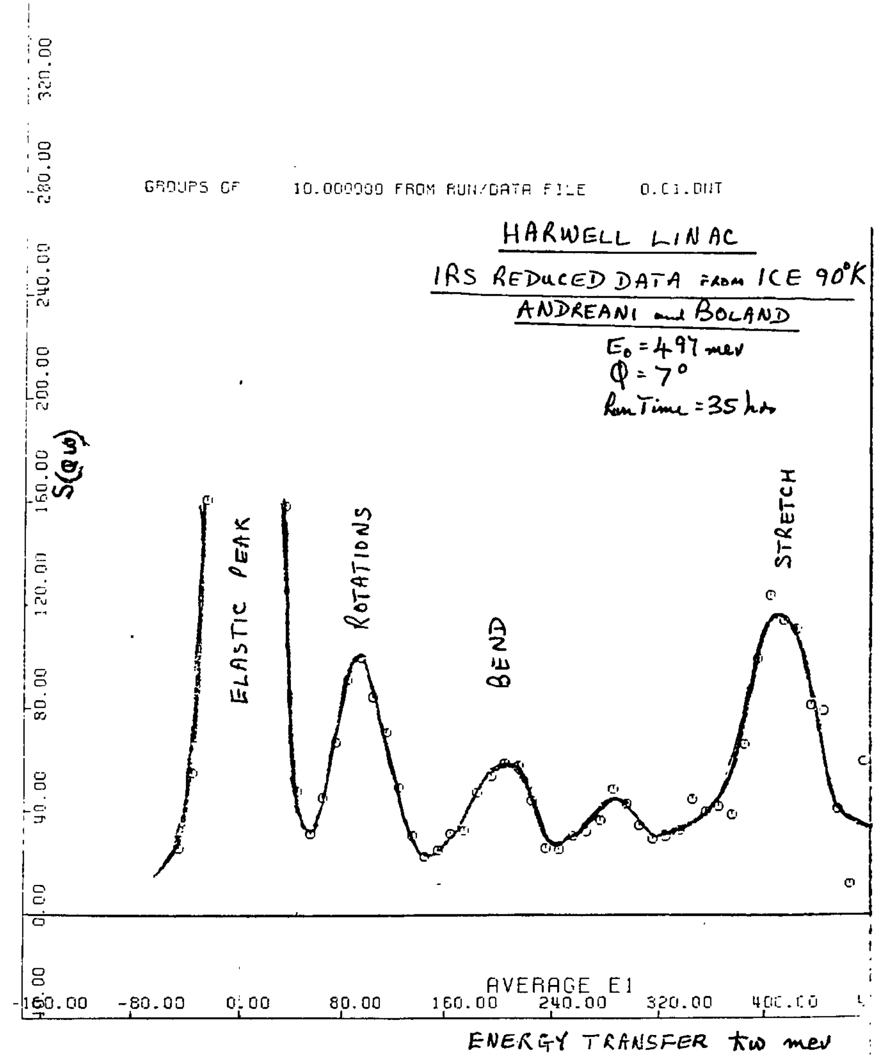

GROUPS OF 10.000000 FROM RUN/DATA FILE 0.C1.DNT
HARWELL LINAC
IRS REDUCED DATA FROM ICE 90°K
ANDREANI and BOLAND
E_0 = 497 mev
ϕ = 7°
Run Time = 35 hrs
S(Q,ω)
ELASTIC PEAK
ROTATIONS
BEND
STRETCH
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
320.00
-160.00
-80.00
0.00
80.00
160.00
240.00
320.00
400.00
AVERAGE E1
ENERGY TRANSFER ħω mev

Fig. 8