University of Kent

Kent Academic Repository

Newport, Robert J., Seeger, P.A. and Williams, W.G. (1985) *Test Measurements On A Resonance Filter Spectrometer Using Electronvolt Neutrons.* Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 238 (1). pp. 177-179. ISSN 0168-9002.

Downloaded from

https://kar.kent.ac.uk/15940/ The University of Kent's Academic Repository KAR

The version of record is available from

https://doi.org/10.1016/0168-9002(85)91045-9

This document version

UNSPECIFIED

DOI for this version

Licence for this version

UNSPECIFIED

Additional information

Versions of research works

Versions of Record

If this version is the version of record, it is the same as the published version available on the publisher's web site. Cite as the published version.

Author Accepted Manuscripts

If this document is identified as the Author Accepted Manuscript it is the version after peer review but before type setting, copy editing or publisher branding. Cite as Surname, Initial. (Year) 'Title of article'. To be published in *Title of Journal* , Volume and issue numbers [peer-reviewed accepted version]. Available at: DOI or URL (Accessed: date).

Enquiries

If you have questions about this document contact ResearchSupport@kent.ac.uk. Please include the URL of the record in KAR. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies).

Nuclear Instruments and Methods in Physics Research A238 (1985) 177–179
North-Holland, Amsterdam

Letter to the Editor

TEST MEASUREMENTS ON A RESONANCE FILTER SPECTROMETER USING ELECTRONVOLT NEUTRONS

R.J. NEWPORT, P.A. SEEGER * and W.G. WILLIAMS

Neutron Division, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11, OQX, England

Received 19 November 1984

Inelastic neutron scattering measurements carried out on a prototype spectrometer at the WNR pulsed neutron facility are presented. Energy transfers are determined by differencing time-of-flight spectra taken with and without absorbing foils containing sharp nuclear resonances which define the scattered neutron energy. The quality of the spectra are enhanced by i) applying a double difference technique to improve line shape and ii) using fixed incident and scattered beam filters which discriminate in favour of the inelastic difference signal.

Ref. [1] describes a proposed method for performing spectroscopic experiments in the electronvolt region using epithermal neutrons. The basic premise of the technique (see fig. 1 of that paper) is to use a foil with a sharp nuclear resonance to analyse the scattered neutron energy in a time-of-flight instrument on a pulsed source. Difference spectra taken with and without this foil identify those neutrons down-scattered to the resonance energy E_R. There are several nuclei with suitable well-separated resonances in the 0.8–10 eV region, thus this allows the determination of much larger energy transfer than are observable with conventional neutron spectrometers at reactor sources.

A novel feature of the proposed instrument was the use of fixed incident and scattered beam filters to enhance the discrimination of the inelastic difference signal. In parallel with this development, Seeger et al. [2] suggested a method of improving the resolution and line shape obtainable by the single difference procedure which involved taking difference spectra between "thick" and "thin" analysing foils; it is commonly called the double difference method. Details of these techniques are provided in the original references, however it is the purpose of this letter to report that they have been combined and applied in a series of measurements carried out on a prototype spectrometer, henceforth called a resonance filter spectrometer (RFS), at the Weapons Neutron Research facility (WNR), Los Alamos National Laboratory. We present the first difference spectra obtained with the spectrometer using a zirconium hydride test scatterer to illustrate the viability of this new experimental method.

The instrument parameters were very similar to those described in ref. [1]: incident flight path 10.16 m, scattered flight path 1.02 m, beam diameter 30 mm and incident beam divergence $\sim 0.4°$. Three scattering angles were available at $\phi = 5.5°$, 10° and 20° with solid angles $\Omega = 0.012$, 0.02 and 0.02 sr respectively. In contrast to the preliminary measurements the ^3He gas detectors were covered with cadmium and, as anticipated, this successfully eliminated the difference signal due to the thermal resonance in the Sm analyser. The proton pulse width from WNR during the period of the tests was approximately ~ 5 μs; this gave a somewhat degraded resolution in comparison with that ultimately achievable with more standard accelerator pulse widths which are typically < 1 μs.

The test scatterer selected for the first measurements was zirconium hydride powder of thickness ~ 2 mm held in a thin Al plate container (total wall thickness ~ 0.2 mm). The hydrogen scattering is well-approximated by an Einstein oscillator model, and provides a series of intrinsically narrow excitation frequencies with progressively smaller cross-sections. This scatterer is therefore suitable for determining the relatively broad resolution of the RFS, and, in combination with calculations [3], can indicate the limits of the observable cross-sections. The inelastic scattering from ZrH_2 was studied using both samarium and tantalum analysing filters, i.e. by down-scattering to $E_R = 0.872$ eV and $E_R = 4.28$ eV respectively.

Fig. 1 shows the derived single and double difference spectra measured at $\phi = 5.5°$ using samarium analysers, as well as computer simulations of the expected scattering. It may be recalled that the elastic scattering is always eliminated in our RFS methods since the incident beam filter contains a thick filter of the same absorber as the analyser [1]. The data demonstrate that the expected features in the spectra are observed, and

* MSH805, Los Alamos National Laboratory, Los Alamos, NM 87545, USA.

0168-9002/85/$03.30 © Elsevier Science Publishers B.V.
(North-Holland Physics Publishing Division)

also that the anticipated improvement in resolution by using the double difference procedure is realized. The overtone at an energy transfer ~420 meV is clearly observable, in contrast to comparable measurements with a ^{240}Pu analyser reported in ref. [4], but where the fixed coarse energy selecting filters were not used. Further data taken at scattering angles $\phi = 10°$ and 20° confirmed the calculated overtone intensity variation as

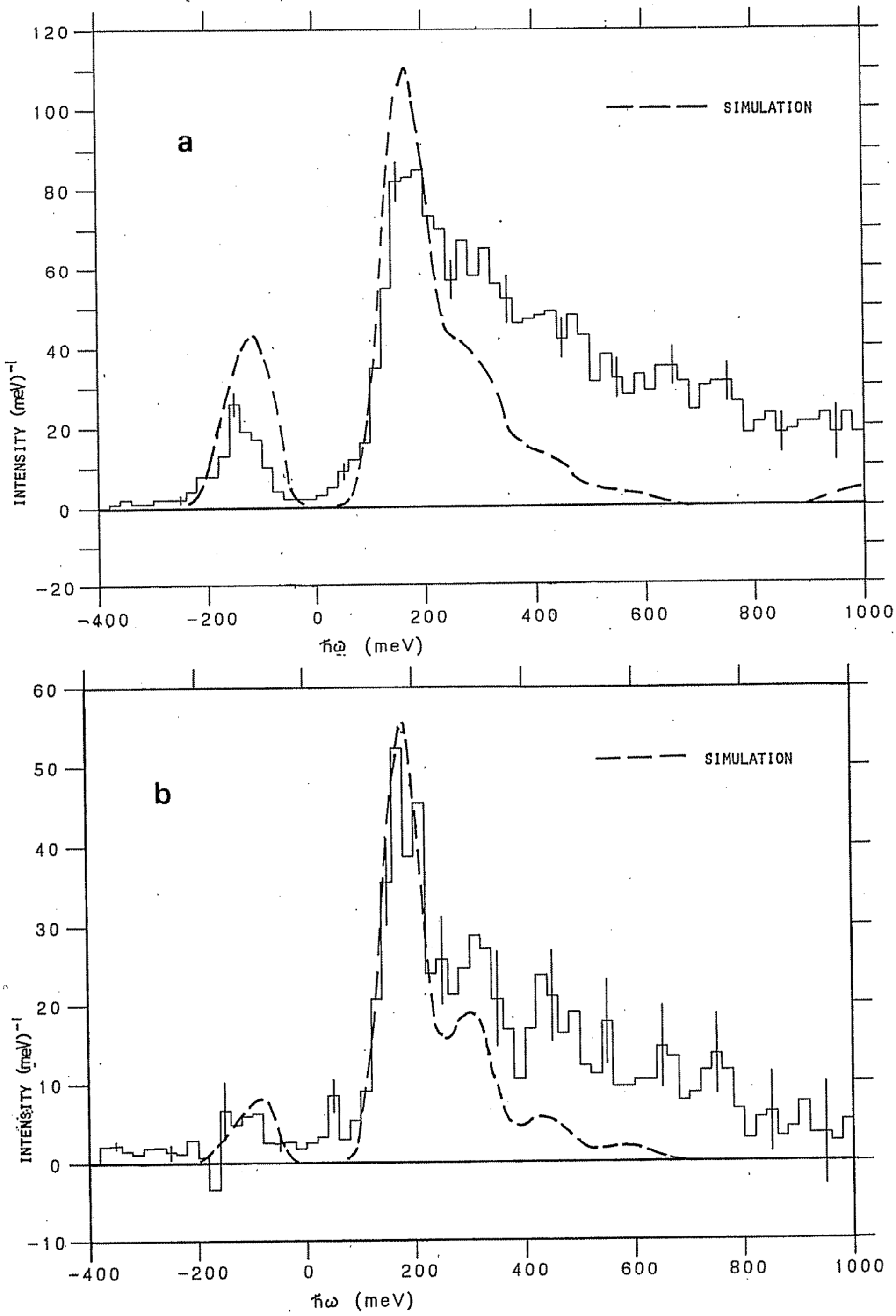

Fig. 1. Inelastic scattering from ZrH_2: (a) single difference and (b) double difference spectra at $\phi = 5.5°$ using samarium analysers.

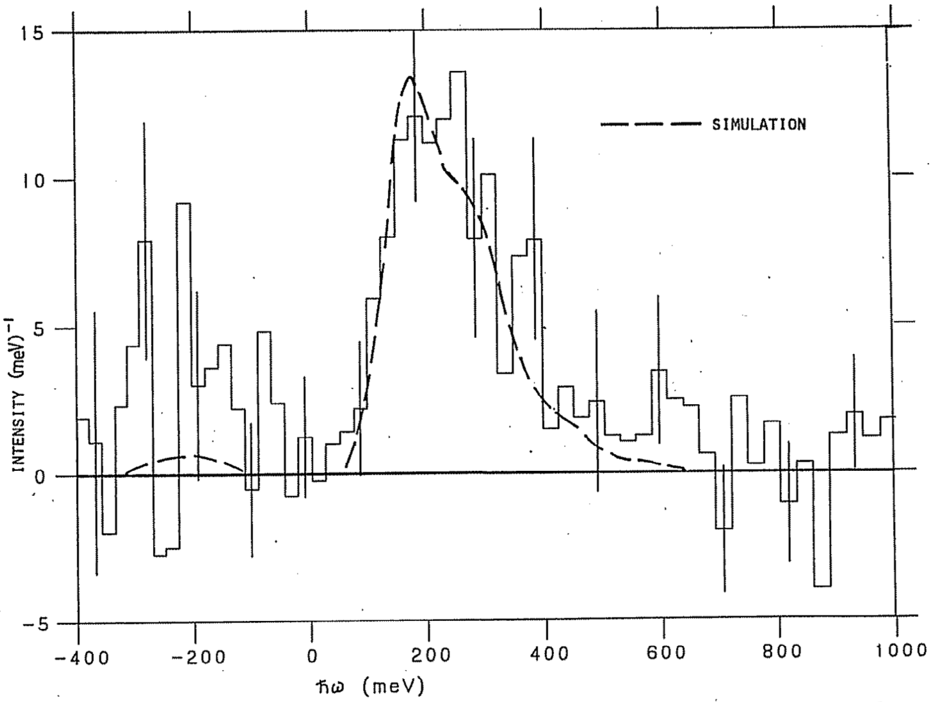

Fig. 2. Inelastic scattering from ZrH_2: double difference spectra at $\phi = 5.5°$ using tantalum analysers.

a function of the scattering vector. By comparing observed and calculated intensities it was also possible to deduce that the RFS, on a source with total proton beam time ~850 μA · h, was capable of measuring differential cross-sections of order 0.1 b sr^{-1} eV^{-1}. The most novel feature of this spectrometer is that this is possible at relatively high excitation energies for condensed matter research (~500 meV) and at low values of the scattering vector (≤ 5 $Å^{-1}$).

A similar series of measurements on ZrH_2 were also performed using tantalum analysing filters. The double difference spectrum at a scattering angle $\phi = 5.5°$, and with ~125 μA · h of proton beam time, is shown in fig. 2. At the tantalum analyser energy ($E_R = 4.28$ eV) the contribution of the relatively long WNR proton pulse with (~5 μs) to the energy transfer resolution is comparable to the term from the analyser resonance width itself, and individual harmonic excitations are not resolved. The data are however consistent with the expected larger recoil energy shift compared with the Sm case, and also illustrates the increased effect of multiphonon scattering. Again the feasibility of the basic method for analysing scattered neutron energies of order several electronvolts has been demonstrated. Significant improvements in both the energy and momentum transfer resolutions can be achieved by using pulsed sources with narrower intrinsic widths, such as the Rutherford Appleton Laboratory SNS [5], and by cooling the analyser filters in order to reduce Doppler broadening effects.

We conclude that by using the resonance filter spectrometer with energy-selective incident and scattered beam filters, together with the double difference procedure to obtain the difference spectra, it is now possible to extend neutron spectroscopic measurements into new regions of dynamic space, i.e. excitations are now observable at energy transfers up to ~500 meV and at low associated scattering vectors ($Q \leq 5$ $Å^{-1}$).

References

[1] R.J. Newport, J. Penfold and W.G. Williams, Nucl. Instr. and Meth. 224 (1984) 120.
[2] P.A. Seeger, A.D. Taylor, and R.M. Brugger, Los Alamos National Laboratory Report LANR-84-1028 (1984).
[3] R.M. Richardson, Rutherford Appleton Laboratory Report RL-82-035 (1982).
[4] A.D. Taylor, R.A. Robinson and P.A. Seeger, Nucl. Instr. and Meth. 224 (1984) 133.
[5] B.E.F. Fender, L.C.W. Hobbis and G. Manning, Phil. Trans. Roy. Soc. London B290 (1980) 657.
Roy. Soc. London B290 (1980) 657.