Abstract. A high resolution neutron spectrometer making use of a \( \Delta T \)-window filter for the analyser and time-of-flight technique for analysing incident neutron energy has been designed. The spectrometer will provide a continuously variable energy resolution \( \Delta E \) from 40-50 \( \mu \text{eV} \) at \( \sim 5230 \, \mu\text{eV} \). The range of energy transfer allowed is \(-1450 \, \mu\text{eV}\) to \(+2950 \, \mu\text{eV}\) and the range of wavevector transfer \( Q \) allowed is \(0.82-3.06 \AA^{-1}\). Depending on the resolution used, the counting rates are expected to vary from \(28-60 \times 10^3 \) counts/hr if one assumes 10\% isotropic elastic scattering from the sample.

Keywords. Neutron spectrometer; window filter; time-of-flight; resolution; intensity, beryllium.

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1. Introduction

A variety of neutron spectrometers have been built in the past for quasi-elastic and inelastic scattering measurements. They differ, mainly, in the manner of their neutron monochromatisation and/or energy analysis, thus resulting in spectrometers with varying regions of accessible wavevector and energy transfers and differing resolutions. They are either based on principles of crystal diffractometry or time-of-flight spectrometry (Iyengar 1965; Brugger 1965; Buras 1968; Windsor 1981). In crystal spectrometers (Iyengar 1965) which always depend on the use of Bragg Law, \( 2d \sin \theta = \lambda \), the energy resolution, \( \Delta E/E \), depends basically on \( \cot \theta \cdot \Delta \theta \) where \( \Delta \theta \) is an effective divergence. While a choice of large \( \theta \), in order to improve the resolution restricts the available range of wave-vector transfer, \( Q \), a reduction of \( \Delta \theta \) beyond a certain value severely affects the intensity. For time-of-flight instruments (Buras 1968; Windsor 1981) the resolution \( \Delta E/E = 2 \Delta t/t \); this requires increasing the total time-of-flight, \( t \), of the neutrons and reducing \( \Delta t \), the effective width in the arrival time of neutrons of a given energy at the detector, for achieving a better resolution. Limitations in achieving better resolution arise due to difficulties associated with the use of long flight paths (to get large \( t \)) and designing of chopping devices (to get shorter \( \Delta t \)). Consequently, the overall energy resolution of conventional spectrometers is seldom better than about 2\%. For example, none of these spectrometers have a resolution better than 100 \( \mu\text{eV} \) at 5000 \( \mu\text{eV} \). Special types of instruments like the back-scattering (Alefeld 1969) and spin-echo (Dagleish et al 1980) spectrometers, on the other hand, have a resolution \( \sim 1 \, \mu\text{eV} \), though the allowed region of energy transfer is limited. Thus, there is a need for improving the energy resolution at a given energy, in order to reduce the resolution gap between the ‘conventional’ and ‘special’ instruments.
This paper describes a new type of spectrometer, called a 'ΔT-window spectrometer', which attempts to do this. The spectrometer will provide an energy resolution of \( \sim 40 \ \mu \text{eV} \) (continuously changeable to \( 50 \ \mu \text{eV} \)) at \( \sim 5230 \ \mu \text{eV} \). The allowable range of energy transfer will be from \(-1450\) to \(+2950\) \( \mu \text{eV} \). To the best of our knowledge, this will be the first spectrometer with such characteristic parameters. It is possible to improve the resolution down to \( 20 \ \mu \text{eV} \), in principle, with some changes in design.

The basic idea of the ΔT-window and a spectrometer based on this have been described earlier (Iyengar 1964; Dasannacharya 1981; Goyal et al. 1982). They are briefly mentioned in §2 for the sake of completeness. The incident beam tailoring required for the spectrometer is described in §3*. The consideration adopted for the design of the sample and ΔT-window analyser systems in order to arrive at the best possible combination of resolution and intensity are given in §4. Using the parameters determined thus, the shape of the resolution function and the anticipated neutron intensity in a typical neutron experiment are evaluated in §5. A preliminary account of this work has been reported earlier (Goyal et al. 1983).

2. Principle of ΔT-window spectrometer

Figure 1 is a schematic drawing of the spectrometer. A pulse of polychromatic neutrons from the neutron source is allowed to travel a long distance, \( L_1 \), before it is incident on the sample. The incident time resolution is \( \Delta t/t = V'(\Delta t/L_1) \), \( V' \) being the velocity of the neutrons. Typically, assuming \( \Delta t = 100 \ \mu \text{sec} \), the anticipated full width at half maximum of the SNS (Manning 1978; Taylor 1982) pulse from the liquid hydrogen cold.

\[ \text{Figure 1. A schematic of the ΔT-window neutron spectrometer with a pulsed source.} \]

* The spectrometer is designed for installation at one of the beams of the Spallation Neutron Source (SNS) at the Rutherford Appleton Laboratory, UK, under a collaboration agreement between the Bhabha Atomic Research Centre (BARC) and the Rutherford Appleton Laboratory. Hence all the design parameters of the instrument are decided with characteristics of SNS in view. The spectrometer has been fabricated at BARC and will be described in detail elsewhere (Dasannacharya et al. 1984).