12

THREE-AXIS INELASTIC NEUTRON SCATTERING

R. CURRAT
Institut Laue-Langevin, Grenoble, France

1. PRINCIPLE OF THE TECHNIQUE

In the field of inelastic neutron scattering, *three-axis* (TAS) and *time-of-flight* (TOF) spectroscopy are the two most general and most widely used techniques. Their respective merits, with reference to specific experiments, will be discussed in some detail further on (see section 3). In general terms, the TAS technique is the technique of choice whenever it is desirable to have a precise control of the positions in ($\boldsymbol{Q}$,ω) space where data are to be collected. With the TAS method ($\boldsymbol{Q}$,ω) space is explored in a step-by-step manner, each spectrometer configuration corresponding to a well-defined value of $\boldsymbol{k}_i$ and $\boldsymbol{k}_f$, the incident and scattered neutron wavevectors, and hence of $\boldsymbol{Q}$ and $\hbar\omega$ [1]

$$\begin{aligned} \boldsymbol{k}_f - \boldsymbol{k}_i &= \boldsymbol{Q} && \text{(a)} \\ \frac{\hbar^2 k_i^{\,2}}{2M_n} - \frac{\hbar^2 k_f^{\,2}}{2M_n} &= \hbar\omega && \text{(b)} \end{aligned} \qquad \{1\}$$

A typical three-axis spectrometer (TAS) set-up is shown schematically in figure 1. The incident neutron wavevector $\boldsymbol{k}_i$ is selected by Bragg reflection on a crystal monochromator (angles labelled $\mathrm{A1} \equiv \theta_m$ and $\mathrm{A2} \equiv 2\theta_m$ in the figure). The orientation of the vector $\boldsymbol{k}_i$ in the specimen's reciprocal space is controlled by orienting the specimen with respect to $\boldsymbol{k}_i$ (rotation around a vertical axis (A3) + double-goniometer or eulerian cradle). The scattered neutron wavevector $\boldsymbol{k}_f$ is

1. Different sign conventions are possible for the momentum and energy transfer variables. The convention in eq. (1.1a) ensures that in Ewald-type constructions (cf. fig. 2 and 3) the vector $\boldsymbol{Q}$ has its origin at the origin of reciprocal space, while the incident and scattered neutron wavevectors, $\boldsymbol{k}_i$ and $\boldsymbol{k}_f$, have a common origin at the centre of the Ewald sphere. With the sign convention in eq. (1.1b) for $\hbar\omega$, positive energy transfer values correspond to neutron energy loss processes (Stokes processes), which are dominant at low temperature.

F. Hippert et al. (eds.), Neutron and X-ray Spectroscopy, 383–425.

selected by Bragg reflection on a crystal analyzer (A5 ≡ θ_a, A6 ≡ $2\theta_a$). The orientation of the vector $\boldsymbol{k}_f$ in the specimen's reciprocal space is determined by the value of the scattering angle at the sample position (A4).

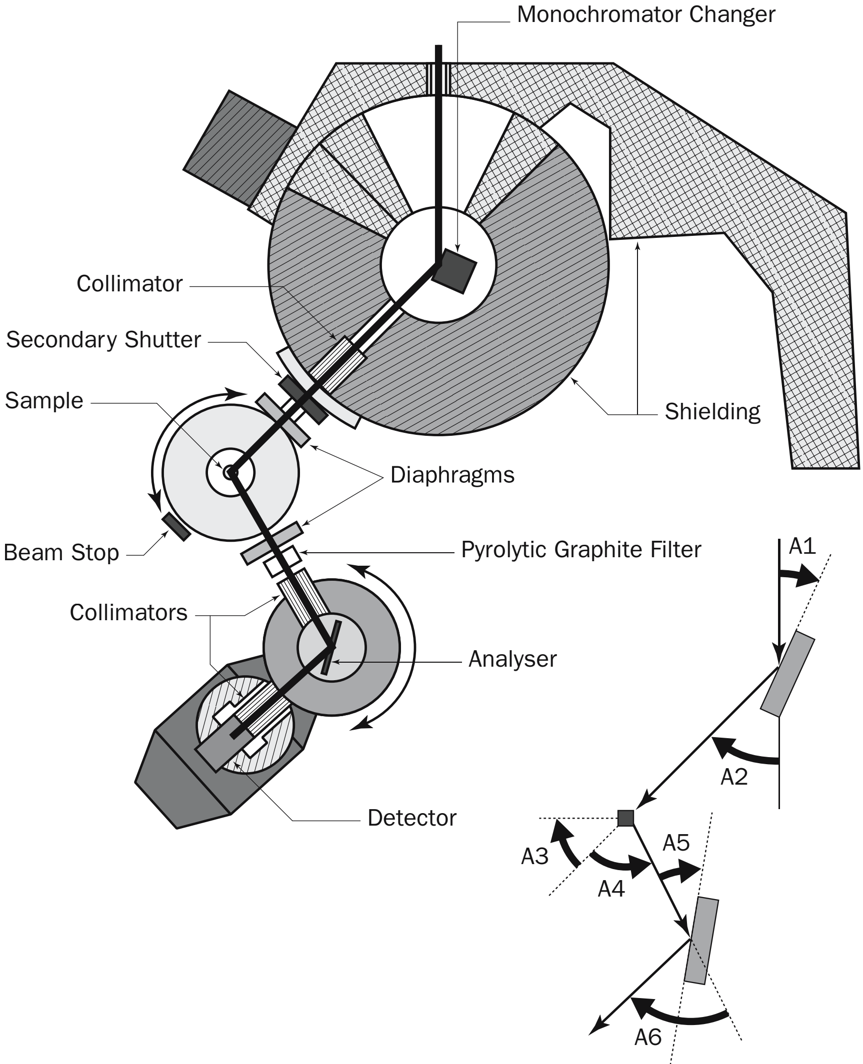

Figure 1 - A typical three-axis spectrometer set-up at a reactor thermal beam-port (IN20 at ILL).

Figure 2 shows the reciprocal space diagram (solid lines) corresponding to the spectrometer configuration in figure 1. We have assumed $k_i \neq k_f$ (finite energy transfer $\hbar\omega$) and we have decomposed the total momentum transfer $\boldsymbol{Q}$ into a