Multi-Analyser Crystals Spectrometer at KENS

K. Tajima, K. Kanai, Y. Ishikawa, S. Tomiyoshi*
and C.G. Windsor

Department of Physics, Tohoku University

* Research Institute for Iron, Steel and Other Metals, Tohoku University

§ Introduction

In order to investigate the neutron inelastic scattering a new type of spectrometer in which a crystal analyser is combined with the TOF method has been proposed by several authors[1~4]. If many analysers and detectors are used in this type of spectrometer, a wide range of $\hbar\omega$-Q space can be explored efficiently and it was based on this principle that we designed the MAX(Multi Analyser Crystal) spectrometer[4]. As described previously[4], the MAX has 15 analyser crystals whose scattering angle can be adjusted independently. In this way scan along the principal direction in reciprocal space can be performed efficiently. The MAX was recently installed at the H5 experimental hole at KENS and we outline below the initial alignment procedure and demonstrate some of our early results.

§ Spectrometer Alignment

As with all crystal analyser spectrometers, it is important that the various zero angles for the scattering angle $2\theta_s$, the analyser angle $2\theta_A$ and the analyser crystal axis ω_A are determined. In Figure 1 we show the definitions of the 3 zero angles which must be defined; $2\theta_s°$, $2\theta_A°$ and $\omega_A°$.

a) Scattering zero angle $2\theta_s°$

Because of the mechanical limitation it is generally

impracticable to rotate the $2\theta_s$ to the straight through position. Each angle can be calibrated independently by elastic diffraction from a powder sample of known lattice spacing. The total flight path L needs to be accurately known since the scattering angle is deduced from the flight time $t_{hk\ell}$ of a reflection of spacing $d_{hk\ell}$. The $2\theta_s°$ can be determined from a equation

$$2\theta_s - 2\theta_s° = 2 \sin^{-1} \left(\frac{\hbar}{m} \frac{t_{hk\ell}}{L} \cdot \frac{\pi}{d_{hk\ell}} \right).$$

b) Analyser arm zero angle $2\theta_A°$

The analyser arem zero angle, $2\theta_A°$, may be determined by measuring the incoherent elastic scattering from vanadium. The above expression becomes

$$2\theta_A - 2\theta_A° = 2 \sin^{-1} \left(\frac{\hbar}{m} \frac{t}{L} \cdot \frac{\pi}{d_A} \right),$$

where d_A is the analyser interplaner spacing and t is the flight time.

c) Analyser crystal zero angle $\omega_A°$

$\omega_A°$ can be accurately determined by using a sample reflection of equal d-spacing to that of analyser. This corresponds to the focussing condition and the width of the reflection from the analyser is a minimum.

§ Measurements

1) Vanadium

The incoherent elastic scattering from a polycrystalline vanadium rod was measured and some typical results are shown in Figure 2. These measurements were used for spectrometer alignment as above and to provide on the information on the analyser reflectivity, detector efficiency and instrumental resolution.

2) Phonons in b.c.c. Fe

A series of phonon spectra along the [100] direction in

Fe-4%Si were measured around the (110), (112) etc. reciprocal lattice points. The scattering diagram and the range of the measurement for some of the analysers is shown in Figure 3. The dotted lines represent the longitudinal and transverse phonon dispersion curves which were measured on a triple axis spectrometer[5]. Some examples of the spectra measured on MAX are shown in Figure 4. The arrows indicate the central position of the (002) reflection and the arrows marked with the letters 'L' or 'T' indicate the positions of the phonons as anticipated on the basis of Figure 3. The other peaks at lower channels are from higher order reflections of the analyser.

The spin wave peak is discernible in the spectra corresponding to $2\theta_s = 47°$, as indicated by the arrow marked with 'M'. This peak corresponds to 'up scattering' spin wave around the (110) reciprocal lattice point. However, mainly because of the low value of the magnetic form factor at higher Q values, no appreciable magnetic peak is observed in the vicinity of the (112) reciprocal lattice point.

Thus we found that the MAX spectrometer could measure the phonon spectra with a good signal to noise ratio. The magnetic excitations would also be detected in a wide range if the measurement would be done around an appropriate reciprocal lattice point, which is now in progress.

References

1) E. Maliszowski et al., "Inelastic Scattering of Neutrons", Vol. II, p. 313, IAEA, 1968.

2) C.G. Windsor et al., Nuc. Inst. Method, 151 (1978) 477.

3) C.G. Windsor, unpublished,

4) K. Tajima et al., KENS report I, KEK Internal. 80-1 p.86(1980).

5) B. Brockhouse et al., Solid State Commun. 5 (1967) 211.

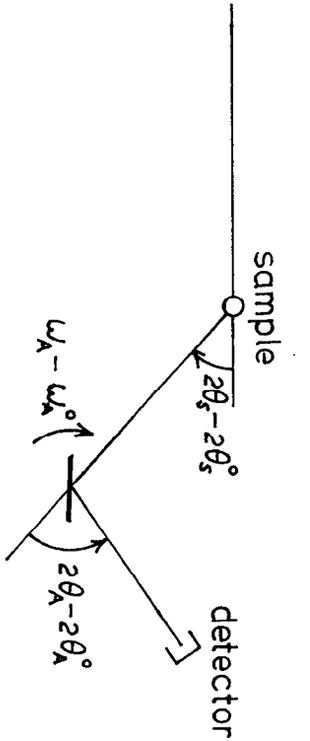

Fig. 1. The definitions of the three angles and their zero angles used in alignment of the spectrometer.

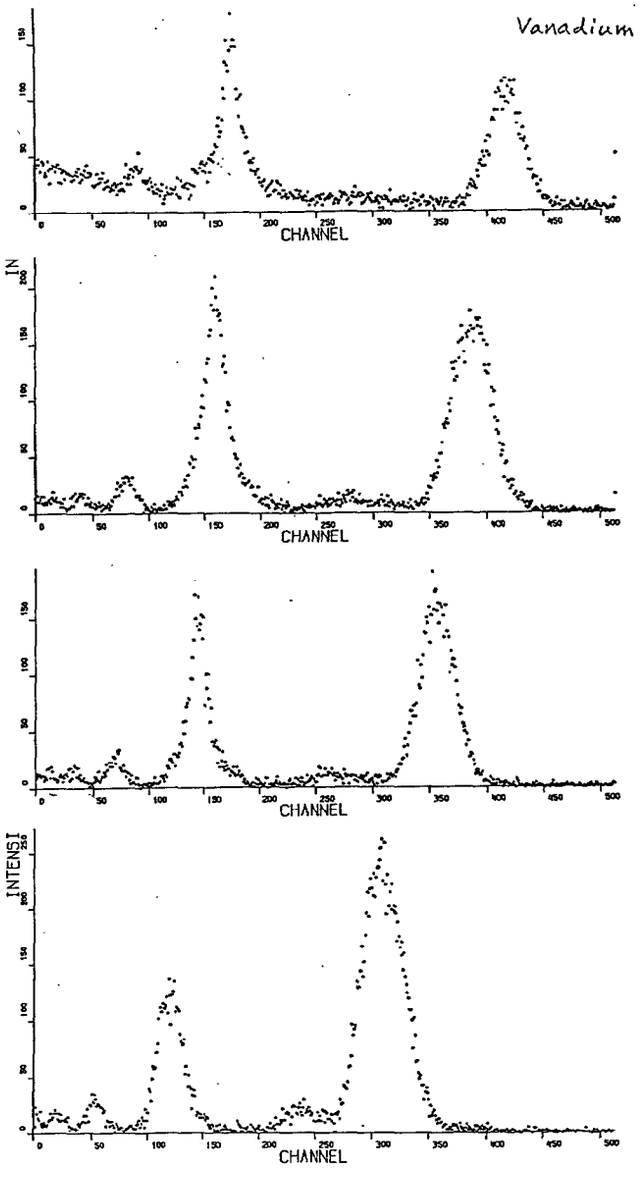

Fig. 2. The incoherent elastic scattering from vanadium.

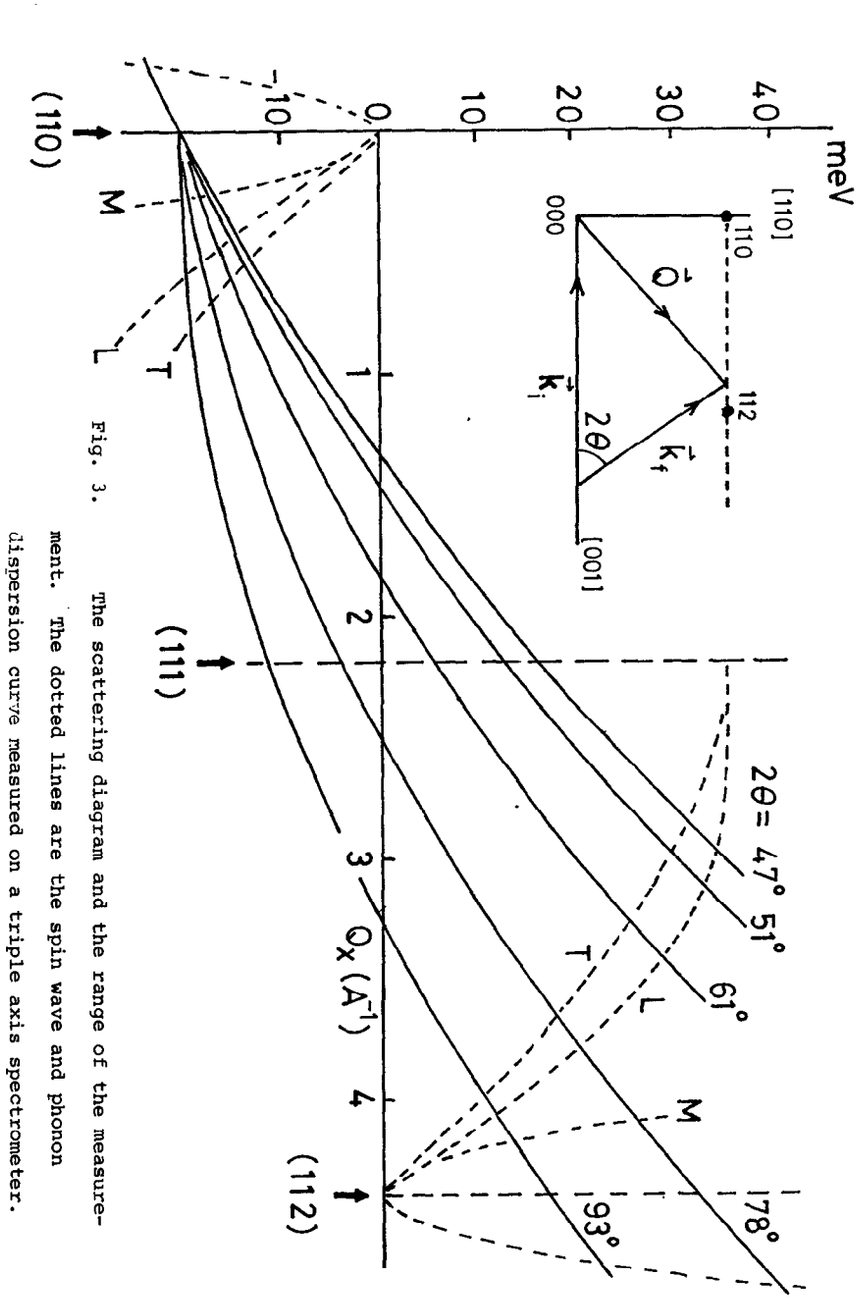

Fig. 3. The scattering diagram and the range of the measurement. The dotted lines are the spin wave and phonon dispersion curve measured on a triple axis spectrometer.

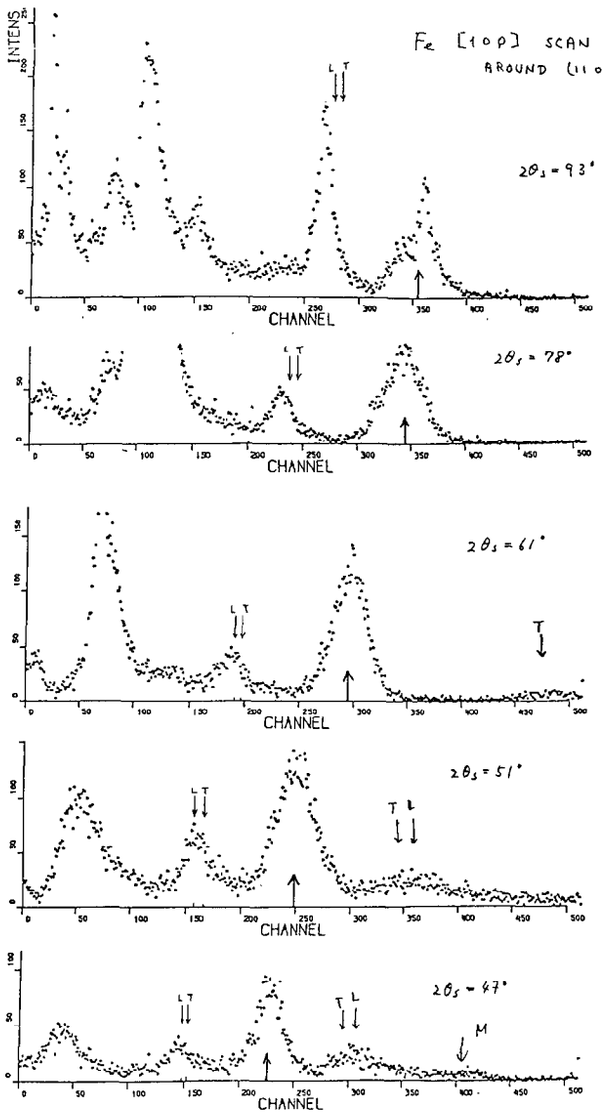

Fig. 4. Some examples of the measured T.O.F. spectra measured on MAX. The measuring time is 40 hours. For details, see text.