11. REAL AND IDEAL CRYSTALS


The total reflection width of a monolithic meander silicon crystal (figure) can be increased by a proper temperature gradient, as tested by thermal neutron diffraction. Although the related intensity profiles are easily calculated the wave functions become very complicated. A meander crystal with a temperature gradient may be a valuable tool for neutron backscattering spectrometers.

Multiple Laue-rocking curves for neutrons show due to their weak absorption, a very narrow central peak, whose angular width is in the order of the ratio of the lattice constant to the thickness of the crystal plate (\( \Delta \theta_{\text{hkl}} / \tan \theta \)). It can be easily observed by using a monolithic designed multiplate system (Bonse et al., Phys. Lett. (1979) 420; Rauch et al., Z. Physik (1983) 519a, 11). Recently we have calculated the related rocking curves analytically, using the two wave field approximation of dynamical diffraction theory (Petrascheck and Rauch, Acta Cryst. (1984) in print). Various contributions to triple Laue-rocking curves are shown in the figure. The narrow central peak is described by the formula

\[
R_p \approx \frac{5 \Delta \theta}{16} \left( \frac{2 \Delta \theta}{4 \Delta \theta} \right) + \left( \frac{4 \Delta \theta}{2 \Delta \theta} \right)^2
\]

which has only a weak dependence on the crystal thickness and on the wave length spread of the beam.

The effects can be useful for high-resolution small angle diffraction experiments on macroscopic objects. Neutron interferometry with two and three plate systems became a valuable new tool of neutron optics in the past (Bonse and Rauch, eds., Neutron Interferometry, Clarendon Press 1979). We have now calculated the inelastic coherent and incoherent scattering of Bloch neutrons by phonons.

The interaction is treated in the first Born approximation in analogy to the usual neutron scattering theory. Coherent and incoherent cross sections are evaluated for the one and two beam cases for both Laue and Bragg geometry. Special attention is paid to the coherent one phonon scattering. The dynamical structure factor reads

\[
\xi_c^{(1)}(q, \mathbf{R}) = \sum_{\mathbf{k}} \frac{\gamma(\omega_0, \mathbf{k})}{q} \frac{1}{2} \sum_{\mathbf{i} \mathbf{j}} v_i^*(\mathbf{R}) v_j(\mathbf{R})
\]

The total reflection width of a monolithic meander crystal is decomposed into a part with lattice periodicity and a non-periodic part, which contains the dynamics of the nuclei. The first part is responsible for the coherent elastic scattering. The eigenstates of such a Hamiltonian are Bloch states, which are known from the dynamical theory of diffraction. The second part defines the interaction potential, which describes inelastic coherent and incoherent scattering of Bloch neutrons by phonons.

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