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indicating transmission geometry in all crystal slabs. In these slabs, which can be called the splitter, the mirrors and the recombiner, the same pair of opposite reflections, in symmetrical Laue geometry, is used three times. In the first slab, the incident beam is coherently split into a transmitted and a diffracted beam. Each of these is then diffracted in the two mirrors, and the resulting beams interfere in the recombiner, again yielding a forward-diffracted and a diffracted beam, the intensities of both of which are measured. This version, the analogue of the Mach–Zehnder interferometer in optics, offers a sizeable space (several cm of path length) where two coherent parallel beams can be submitted to various external actions. Shifting the relative phase of these beams (*e.g.* by π, introducing an optical path-length difference of $\lambda/2$) results in the intensities of the outgoing beams changing from a maximum to a minimum.

Applications of neutron interferometry range from the very useful to the very exotic. The most useful one is probably the measurement of coherent neutron scattering lengths. Unlike the *Pendellösung* method described in Section 5.3.7.2, this method does not require the measured samples to be perfect single crystals, nor indeed crystals. Placing a slab of material across one of the beams and rotating it will induce an optical path-length difference of $(1-n)t$ if t is the effective thickness along the beam, hence a phase shift of $2\pi(1-n)t/\lambda$. With the expression of the refractive index n as given in Section 5.3.2.2, it is clear that for an isotopically pure material the scattering length $b_{\rm coh}$ can be deduced from the measurement of intensity *versus* the rotation angle of the phase shifter. This is a very versatile and much used method. The decrease in oscillation contrast can be used to obtain information of relevance to materials science, such as statistical properties of magnetic domain distributions (Korpiun, 1966) or precipitates (Rauch & Seidl, 1987); Rauch (1995) analyses the effect in terms of the neutron coherence function.

Many elegant experiments have been performed with neutron interferometers in efforts to set an upper limit to effects than can be considered as nonexistent, or to test expectations of basic quantum physics. Many papers are found in the same volumes as Bonse (1979) and Bonse (1988); excellent reviews have been given by Klein & Werner (1983), Klein (1988) and Werner (1995). Among the topics investigated are the effect of gravity (Colella *et al.*, 1975), the Sagnac effect, *i.e.* the influence of the Earth's rotation (Werner *et al.*, 1979), the Fizeau effect, *i.e.* the effect of the movement of the material through which the neutrons are transmitted (Arif *et al.*, 1988) and the Aharonov–Casher effect, *i.e.* the dual of the Aharonov–Bohm effect for neutral particles having a magnetic moment (Cimmino *et al.*, 1989).

5.3.7.4. Neutron diffraction topography and other imaging methods

These are the neutron form of the 'topographic' or diffraction imaging techniques, in which an image of a single crystal is obtained through the local variations in Bragg-diffracted intensity due to inhomogeneities in the sample. It is briefly described in Chapter 2.8 of *IT* C. It was pioneered by Doi *et al.* (1971) and by Ando & Hosoya (1972). Like its X-ray counterpart, neutron topography can reveal isolated defects, such as dislocations (Schlenker *et al.*, 1974; Malgrange *et al.*, 1976). Because of the small neutron fluxes available, it is not very convenient for this purpose, since the resolution is poor or the exposure times are very long. On the other hand, the very low absorption of neutrons in most materials makes it quite convenient for observing the gross defect structure in samples that would be too absorbing for X-rays (Tomimitsu & Doi, 1974; Baruchel *et al.*, 1978; Tomimitsu *et al.*, 1983; Kvardakov *et al.*, 1992), or the spatial modulation of distortion due to vibration, for example in quartz (Michalec *et al.*, 1975), and resonant magnetoelastic effects (Kvardakov & Somenkov, 1991). In particular, virtual slices of bulky as-grown samples can be investigated without cutting them using neutron section topography or neutron tomography (Schlenker *et al.*, 1975; Davidson & Case, 1976).

Neutron topography also shows the salient dynamical interference effect, *viz Pendellösung*, visually, in the form of fringes (Kikuta *et al.*, 1971; Malgrange *et al.*, 1976; Tomimitsu & Zeyen, 1978). Its unique feature, however, is the possibility of observing and directly characterizing inhomogeneities in the magnetic structure, *i.e.* magnetic domains of all kinds [ferromagnetic domains (Schlenker & Shull, 1973) and antiferromagnetic domains of various sorts (Schlenker & Baruchel, 1978), including spin-density wave domains (Ando & Hosoya, 1972, 1978; Davidson *et al.*, 1974), 180° or time-reversed domains in some materials and helimagnetic or chirality domains (Baruchel *et al.*, 1990)], or coexisting phases at a first-order phase transition (Baruchel, 1989). In such cases, the contrast is primarily due to local variations in the structure factor, a situation very unusual in X-ray topography, and good crystal quality, leading to dynamical scattering behaviour, is essential in the observation process only in a few cases (Schlenker *et al.*, 1978). It is often crucial, however, for making the domain structure simple enough to be resolved, in particular in the case of antiferromagnetic domains.

Imaging can also be performed for samples that need be neither crystals nor perfect. Phase-contrast imaging of a specimen through which the neutrons are transmitted can be performed in a neutron interferometer. It has been shown to reveal thickness variations by Bauspiess *et al.* (1978) and ferromagnetic domains by Schlenker *et al.* (1980). The same papers showed that phase edges show up as contrast when one of the interferometer paths is blocked, *i.e.* when the sample is placed effectively between perfect, identical crystals set for diffraction in a nondispersive setting. Under the name of neutron radiography with refraction contrast, this technique, essentially a form of Schlieren imaging, was further developed by Podurets, Somenkov & Shil'shtein (1989), Podurets, Somenkov, Chistyakov & Shil'shtein (1989), and Podurets *et al.* (1991), who were able to image internal ferromagnetic domain walls in samples 10 mm thick.

References

Albertini, G., Boeuf, A., Cesini, G., Mazkedian, S., Melone, S. & Rustichelli, F. (1976). *A simple model for dynamical neutron diffraction by deformed crystals. Acta Cryst.* A**32**, 863–868.

Albertini, G., Boeuf, A., Klar, B., Lagomarsino, S., Mazkedian, S., Melone, S., Puliti, P. & Rustichelli, F. (1977). *Dynamical neutron diffraction by curved crystals in the Laue geometry. Phys. Status Solidi A*, **44**, 127–136.

Albertini, G., Boeuf, A., Lagomarsino, S., Mazkedian, S., Melone, S. & Rustichelli, F. (1976). *Neutron properties of curved monochromators. Proceedings of the Conference on Neutron Scattering, Gatlinburg, Tennessee*, USERDA CONF 760601-P2, 1151–1158. Oak Ridge, Tennessee: Oak Ridge National Laboratory.

Al Haddad, M. & Becker, P. J. (1988). *On the statistical dynamical theory of diffraction: application to silicon. Acta Cryst.* A**44**, 262–270.

Ando, M. & Hosoya, S. (1972). *Q-switch and polarization domains in antiferromagnetic chromium observed with neutron-diffraction topography. Phys. Rev. Lett.* **29**, 281–285.

Ando, M. & Hosoya, S. (1978). *Size and behavior of antiferromagnetic domains in Cr directly observed with X-ray and neutron topography. J. Appl. Phys.* **49**, 6045–6051.

Arif, M., Kaiser, H., Clothier, R., Werner, S. A., Berliner, R., Hamilton, W. A., Cimmino, A. & Klein, A. G. (1988). *Fizeau effect for neutrons passing through matter at a nuclear resonance. Physica B*, **151**, 63–67.

Arthur, J. & Horne, M. A. (1985). *Boundary conditions in dynamical neutron diffraction. Phys. Rev. B*, **32**, 5747–5752.

Bacon, G. E. & Lowde, R. D. (1948). *Secondary extinction and neutron crystallography. Acta Cryst.* **1**, 303–314.

Badurek, G., Rauch, H., Wilfing, A., Bonse, U. & Graeff, W. (1979). *A perfect-crystal neutron polarizer as an application of magnetic prism refraction. J. Appl. Cryst.* **12**, 186–191.

Baruchel, J. (1989). *The contribution of neutron and synchrotron radiation topography to the investigation of first-order magnetic phase transitions. Phase Transit.* **14**, 21–29.

Baruchel, J., Guigay, J. P., Mazuré-Espejo, C., Schlenker, M. & Schweizer, J. (1982). *Observation of Pendellösung effect in polarized neutron scattering from a magnetic crystal. J. Phys.* **43**, C7, 101–106.

Baruchel, J., Patterson, C. & Guigay, J. P. (1986). *Neutron diffraction investigation of the nuclear and magnetic extinction in MnP. Acta Cryst.* A**42**, 47–55.

Baruchel, J., Schlenker, M. & Palmer, S. B. (1990). *Neutron diffraction topographic investigations of "exotic" magnetic domains. Nondestruct. Test. Eval.* **5**, 349–367.

Baruchel, J., Schlenker, M., Zarka, A. & Pétroff, J. F. (1978). *Neutron diffraction topographic investigation of growth defects in natural lead carbonate single crystals. J. Cryst. Growth*, **44**, 356–362.

Baryshevskii, V. G. (1976). *Particle spin precession in antiferromagnets. Sov. Phys. Solid State*, **18**, 204–208.

Bauspiess, W., Bonse, U., Graeff, W., Schlenker, M. & Rauch, H. (1978). Result shown in Bonse (1979).

Becker, P. & Al Haddad, M. (1990). *Diffraction by a randomly distorted crystal. I. The case of short-range order. Acta Cryst.* A**46**, 123–129.

Becker, P. & Al Haddad, M. (1992). *Diffraction by a randomly distorted crystal. II. General theory. Acta Cryst.* A**48**, 121–134.

Becker, P. J. & Coppens, P. (1974*a*). *Extinction within the limit of validity of the Darwin transfer equations. I. General formalisms for primary and secondary extinction and their application to spherical crystals. Acta Cryst.* A**30**, 129–147.

Becker, P. J. & Coppens, P. (1974*b*). *Extinction within the limit of validity of the Darwin transfer equations. II. Refinement of extinction in spherical crystals of SrF_2 and LiF. Acta Cryst.* A**30**, 148–153.

Becker, P. J. & Coppens, P. (1975). *Extinction within the limit of validity of the Darwin transfer equations. III. Non-spherical crystals and anisotropy of extinction. Acta Cryst.* A**31**, 417–425.

Belova, N. E., Eichhorn, F., Somenkov, V. A., Utemisov, K. & Shil'shtein, S. Sh. (1983). *Analyse der Neigungsmethode zur Untersuchung von Pendellösungsinterferenzen von Neutronen und Röntgenstrahlen. Phys. Status Solidi A*, **76**, 257–265.

Belyakov, V. A. & Bokun, R. Ch. (1975). *Dynamical theory of neutron diffraction by perfect antiferromagnetic crystals. Sov. Phys. Solid State*, **17**, 1142–1145.

Belyakov, V. A. & Bokun, R. Ch. (1976). *Dynamical theory of neutron diffraction in magnetic crystals. Sov. Phys. Solid State*, **18**, 1399–1402.

Boeuf, A. & Rustichelli, F. (1974). *Some neutron diffraction experiments on curved silicon crystals. Acta Cryst.* A**30**, 798–805.

Bokun, R. Ch. (1979). *Beats in the integrated intensity in neutron diffraction by perfect magnetic crystals. Sov. Phys. Tech. Phys.* **24**, 723–724.

Bonnet, M., Delapalme, A., Becker, P. & Fuess, H. (1976). *Polarised neutron diffraction – a tool for testing extinction models: application to yttrium iron garnet. Acta Cryst.* A**32**, 945–953.

Bonse, U. (1979). *Principles and methods of neutron interferometry*. In *Neutron Interferometry: Proceedings of an International Workshop*, edited by U. Bonse & H. Rauch, pp. 3–33. Oxford: Clarendon Press.

Bonse, U. (1988). *Recent advances in X-ray and neutron interferometry. Physica B*, **151**, 7–21.

Bonse, U. & Hart, M. (1965). *An X-ray interferometer. Appl. Phys. Lett.* **6**, 155–156.

Chakravarthy, R. & Madhav Rao, L. (1980). *A simple method to correct for secondary extinction in polarised-neutron diffractometry. Acta Cryst.* A**36**, 139–142.

Chalupa, B., Michalec, R., Horalik, L. & Mikula, P. (1986). *The study of neutron acoustic effect by neutron diffraction on InSb single crystal. Phys. Status Solidi A*, **97**, 403–409.

Cimmino, A., Opat, G. I., Klein, A. G., Kaiser, H., Werner, S. A., Arif, M. & Clothier, R. (1989). *Observation of the topological Aharonov–Casher phase shift by neutron interferometry. Phys. Rev. Lett.* **63**, 380–383.

Colella, R., Overhauser, A. W. & Werner, S. A. (1975). *Observation of gravitationally induced quantum interference. Phys. Rev. Lett.* **34**, 1472–1474.

Davidson, J. B. & Case, A. L. (1976). *Applications of the fly's eye neutron camera: diffraction tomography and phase transition studies. Proceedings of the Conference on Neutron Scattering, Gatlinburg, Tennessee*, USERDA CONF 760601-P2, 1124–1135. Oak Ridge, Tennessee: Oak Ridge National Laboratory.

Davidson, J. B., Werner, S. A. & Arrott, A. S. (1974). *Neutron microscopy of spin density wave domains in chromium. Proceedings of the 19th Annual Conference on Magnetism and Magnetic Materials*, edited by C. D. Graham and J. J. Rhyne. *AIP Conf. Proc.* **18**, 396–400.

Doi, K., Minakawa, N., Motohashi, H. & Masaki, N. (1971). *A trial of neutron diffraction topography. J. Appl. Cryst.* **4**, 528–530.

Eichhorn, F. (1988). *Perfect crystal neutron optics. Physica B*, **151**, 140–146.

Eichhorn, F., Sippel, D. & Kleinstück, K. (1967). *Influence of oxygen segregations in silicon single crystals on the halfwidth of the double-crystal rocking curve of thermal neutrons. Phys. Status Solidi*, **23**, 237–240.

Guigay, J. P. (1989). *On integrated intensities in Kato's statistical diffraction theory. Acta Cryst.* A**45**, 241–244.

Guigay, J. P. & Chukhovskii, F. N. (1992). *Reformulation of the dynamical theory of coherent wave propagation by randomly distorted crystals. Acta Cryst.* A**48**, 819–826.

Guigay, J. P. & Chukhovskii, F. N. (1995). *Reformulation of the statistical theory of dynamical diffraction in the case E = 0. Acta Cryst.* A**51**, 288–294.

Guigay, J. P. & Schlenker, M. (1979*a*). *Integrated intensities and flipping ratios in neutron diffraction by perfect magnetic crystals*. In *Neutron Interferometry*, edited by U. Bonse & H. Rauch, pp. 135–148. Oxford: Clarendon Press.

Guigay, J. P. & Schlenker, M. (1979*b*). *Spin rotation of the forward diffracted beam in neutron diffraction by perfect magnetic crystals. J. Magn. Magn. Mater.* **14**, 340–343.

Hart, M. & Rodrigues, A. R. D. (1978). *Harmonic-free single-crystal monochromators for neutrons and X-rays. J. Appl. Cryst.* **11**, 248–253.

Hastings, J. B., Siddons, D. P. & Lehmann, M. (1990). *Diffraction broadening and suppression of the inelastic channel in resonant neutron scattering. Phys. Rev. Lett.* **64**, 2030–2033.

Horne, M. A., Finkelstein, K. D., Shull, C. G., Zeilinger, A. & Bernstein, H. J. (1988). *Neutron spin – Pendellösung resonance. Physica B*, **151**, 189–192.

Indenbom, V. L. (1979). *Diffraction focusing of neutrons. JETP Lett.* **29**, 5–8.

International Tables for Crystallography (2004). Vol. C. *Mathematical, Physical and Chemical Tables*, edited by E. Prince. Dordrecht: Kluwer Academic Publishers.

Iolin, E. M. & Entin, I. R. (1983). *Dynamic diffraction of neutrons by high-frequency acoustic waves in perfect crystals. Sov. Phys. JETP*, **58**, 985–989.

Iolin, E. M., Zolotoyabko, E. V., Raïtman, E. A., Kuvdaldin, B. V. & Gavrilov, V. N. (1986). *Interference effects in dynamic neutron diffraction under conditions of ultrasonic excitation. Sov. Phys. JETP*, **64**, 1267–1271.

Kagan, Yu. & Afanas'ev, A. M. (1966). *Suppression of inelastic channels in resonance scattering of neutrons in regular crystals. Sov. Phys. JETP*, **22**, 1032–1040.

Kato, N. (1980*a*). *Statistical dynamical theory of crystal diffraction. I. General formulation. Acta Cryst.* A**36**, 763–769.

Kato, N. (1980*b*). *Statistical dynamical theory of crystal diffraction. II. Intensity distribution and integrated intensity in the Laue cases. Acta Cryst.* A**36**, 770–778.

Kikuta, S., Ishikawa, I., Kohra, K. & Hoshino, S. (1975). *Studies on dynamical diffraction phenomena of neutrons using properties of wave fan. J. Phys. Soc. Jpn*, **39**, 471–478.

Kikuta, S., Kohra, K., Minakawa, N. & Doi, K. (1971). *An observation of neutron Pendellösung fringes in a wedge-shaped silicon single crystal. J. Phys. Soc. Jpn*, **31**, 954–955.

Klar, B. & Rustichelli, F. (1973). *Dynamical neutron diffraction by ideally curved crystals. Nuovo Cimento B*, **13**, 249–271.

Klein, A. G. (1988). *Schrödinger inviolate: neutron optical searches for violations of quantum mechanics. Physica B*, **151**, 44–49.

Klein, A. G. & Werner, S. A. (1983). *Neutron optics. Rep. Prog. Phys.* **46**, 259–335.

Knowles, J. W. (1956). *Anomalous absorption of slow neutrons and X-rays in nearly perfect single crystals. Acta Cryst.* **9**, 61–69.

Korpiun, P. (1966). *Untersuchung ferromagnetischer Strukturen mit einem Zweistrahl-Neutroneninterferometer. Z. Phys.* **195**, 146–170.

Kulda, J. (1988*a*). *The RED extinction model. I. An upgraded formalism. Acta Cryst.* A**44**, 283–285.

Kulda, J. (1988*b*). *The RED extinction model. II. Refinement of extinction and thermal vibration parameters for SrF_2 crystals. Acta Cryst.* A**44**, 286–290.

Kulda, J. (1991). *The RED extinction model. III. The case of pure primary extinction. Acta Cryst.* A**47**, 775–779.

Kulda, J., Baruchel, J., Guigay, J.-P. & Schlenker, M. (1991). *Extinction effects in polarized neutron diffraction from magnetic crystals. I. Highly perfect MnP and YIG samples. Acta Cryst.* A**47**, 770–775.

Kulda, J., Vrána, M. & Mikula, P. (1988). *Neutron diffraction by vibrating crystals. Physica B*, **151**, 122–129.

Kvardakov, V. V., Podurets, K. M., Baruchel, J. & Sandonis, J. (1995). *Precision determination of the structure factors of magnetic neutron scattering from the Pendellösung data. Crystallogr. Rep.* **40**, 330–331.

Kvardakov, V. V., Podurets, K. M., Chistyakov, R. R., Shil'shtein, S. Sh., Elyutin, N. O., Kulidzhanov, F. G., Bradler, J. & Kadečková, S. (1987). *Modification of the domain structure of a silicon–iron single crystal as a result of uniaxial stretching. Sov. Phys. Solid State*, **29**, 228–232.

Kvardakov, V. V. & Somenkov, V. A. (1990). *Observation of dynamic oscillations of intensity of magnetic scattering of neutrons with variation of the orientation of magnetic moments of the sublattices. Sov. Phys. Crystallogr.* **35**, 619–622.

Kvardakov, V. V. & Somenkov, V. A. (1991). *Neutron diffraction study of nonlinear magnetoacoustic effects in perfect crystals of* $FeBO_3$ *and* α-Fe_2O_3. *J. Moscow Phys. Soc.* **1**, 33–57.

Kvardakov, V. V. & Somenkov, V. A. (1992). *Magnetic Pendellösung effects in neutron scattering by perfect magnetic crystals. Acta Cryst.* A**48**, 423–430.

Kvardakov, V. V., Somenkov, V. A. & Shil'shtein, S. Sh. (1990*a*). *Observation of dynamic oscillations in the temperature dependence of the intensity of the magnetic scattering of neutrons. Sov. Phys. Solid State*, **32**, 1097–1098.

Kvardakov, V. V., Somenkov, V. A. & Shil'shtein, S. Sh. (1990*b*). *Influence of an orientational magnetic transition in* α-Fe_2O_3 *on the Pendellösung fringe effect in neutron scattering. Sov. Phys. Solid State*, **32**, 1250–1251.

Kvardakov, V. V., Somenkov, V. A. & Shil'shtein, S. Sh. (1992). *Study of defects in cuprate single crystals by the neutron topography and selective etching methods. Superconductivity*, **5**, 623–629.

Lambert, D. & Malgrange, C. (1982). *X-ray and neutron integrated intensity diffracted by perfect crystals in transmission. Z. Naturforsch. Teil A*, **37**, 474–484.

Malgrange, C., Pétroff, J. F., Sauvage, M., Zarka, A. & Englander, M. (1976). *Individual dislocation images and Pendellösung fringes in neutron topographs. Philos. Mag.* **33**, 743–751.

Mendiratta, S. K. & Blume, M. (1976). *Dynamical theory of thermal neutron scattering. I. Diffraction from magnetic crystals. Phys. Rev.* **14**, 144–154.

Michalec, R., Mikula, P., Sedláková, L., Chalupa, B., Zelenka, J., Petržílka, V. & Hrdlička, Z. (1975). *Effects of thickness-shear vibrations on neutron diffraction by quartz single crystals. J. Appl. Cryst.* **8**, 345–351.

Michalec, R., Mikula, P., Vrána, M., Kulda, J., Chalupa, B. & Sedláková, L. (1988). *Neutron diffraction by perfect crystals excited into mechanical resonance vibrations. Physica B*, **151**, 113–121.

Podurets, K. M., Sokol'skii, D. V., Chistyakov, R. R. & Shil'shtein, S. Sh. (1991). *Reconstruction of the bulk domain structure of silicon iron single crystals from neutron refraction images of internal domain walls. Sov. Phys. Solid State*, **33**, 1668–1672.

Podurets, K. M., Somenkov, V. A., Chistyakov, R. R. & Shil'shtein, S. Sh. (1989). *Visualization of internal domain structure of silicon iron crystals by using neutron radiography with refraction contrast. Physica B*, **156–157**, 694–697.

Podurets, K. M., Somenkov, V. A. & Shil'shtein, S. Sh. (1989). *Neutron radiography with refraction contrast. Physica B*, **156–157**, 691–693.

Rauch, H. (1995). *Towards interferometric Fourier spectroscopy. Physica B*, **213–214**, 830–832.

Rauch, H. & Petrascheck, D. (1978). *Dynamical neutron diffraction and its application*. In *Neutron Diffraction*, edited by H. Dachs, *Topics in Current Physics*, Vol. 6 pp. 305–351. Berlin: Springer.

Rauch, H. & Seidl, E. (1987). *Neutron interferometry as a new tool in condensed matter research. Nucl. Instrum. Methods A*, **255**, 32–37.

Raum, K., Koellner, M., Zeilinger, A., Arif, M. & Gähler, R. (1995). *Effective-mass enhanced deflection of neutrons in noninertial frames. Phys. Rev. Lett.* **74**, 2859–2862.

Scherm, R. & Fåk, B. (1993). *Neutrons*. In *Neutron and Synchrotron Radiation for Condensed Matter Studies (HERCULES Course)*, Vol. 1, edited by J. Baruchel, J. L. Hodeau, M. S. Lehmann, J. R. Regnard & C. Schlenker, pp. 113–143. Les Ulis: Les Editions de Physique and Heidelberg: Springer-Verlag.

Schlenker, M. & Baruchel, J. (1978). *Neutron techniques for the observation of ferro- and antiferromagnetic domains. J. Appl. Phys.* **49**, 1996–2001.

Schlenker, M., Baruchel, J., Perrier de la Bathie, R. & Wilson, S. A. (1975). *Neutron-diffraction section topography: observing crystal slices before cutting them. J. Appl. Phys.* **46**, 2845–2848.

Schlenker, M., Baruchel, J., Pétroff, J. F. & Yelon, W. B. (1974). *Observation of subgrain boundaries and dislocations by neutron diffraction topography. Appl. Phys. Lett.* **25**, 382–384.

Schlenker, M., Bauspiess, W., Graeff, W., Bonse, U. & Rauch, H. (1980). *Imaging of ferromagnetic domains by neutron interferometry. J. Magn. Magn. Mater.* **15–18**, 1507–1509.

Schlenker, M., Linares-Galvez, J. & Baruchel, J. (1978). *A spin-related contrast effect: visibility of 180° ferromagnetic domain walls in unpolarized neutron diffraction topography. Philos. Mag. B*, **37**, 1–11.

Schlenker, M. & Shull, C. G. (1973). *Polarized neutron techniques for the observation of ferromagnetic domains. J. Appl. Phys.* **44**, 4181–4184.

Schmidt, H. H. (1983). *Theoretical investigations of the dynamical neutron diffraction by magnetic single crystals. Acta Cryst.* A**39**, 679–682.

Schmidt, H. H., Deimel, P. & Daniel, H. (1975). *Dynamical diffraction of thermal neutrons by absorbing magnetic crystals. J. Appl. Cryst.* **8**, 128–131.

Sears, V. F. (1978). *Dynamical theory of neutron diffraction. Can. J. Phys.* **56**, 1261–1288.

Shil'shtein, S. Sh., Somenkov, V. A. & Dokashenko, V. P. (1971). *Suppression of* (n, γ) *reaction in resonant scattering of neutrons by a perfect CdS crystal. JETP Lett.* **13**, 214–217.

Shull, C. G. (1968). *Observation of Pendellösung fringe structure in neutron diffraction. Phys. Rev. Lett.* **21**, 1585–1589.

Shull, C. G. (1986). *Neutron interferometer systems – types and features. Physica B*, **136**, 126–130.

Shull, C. G. & Oberteuffer, J. A. (1972). *Spherical wave neutron propagation and Pendellösung fringe structure in silicon. Phys. Rev. Lett.* **29**, 871–874.

Shull, C. G., Zeilinger, A., Squires, G. L., Horne, M. A., Atwood, D. K. & Arthur, J. (1980). *Anomalous flight time of neutrons through diffracting crystals. Phys. Rev. Lett.* **44**, 1715–1718.

Sippel, D. & Eichhorn, F. (1968). *Anomale inkohärente Streuung thermicher Neutronen bei Bildung stehender Neutronenwellen in nahezu idealen Kristallen von Kaliumdihydrogenphosphat (KDP). Acta Cryst.* A**24**, 237–239.

Sippel, D., Kleinstück, K. & Schulze, G. E. R. (1962). *Nachweis der anomalen Absorption thermischer Neutronen bei Interferenz am Idealkristall. Phys. Status Solidi*, **2**, K104–K105.

Sippel, D., Kleinstück, K. & Schulze, G. E. R. (1964). *Neutron diffraction of ideal crystals using a double crystal spectrometer. Phys. Lett.* **8**, 241–242.

Sippel, D., Kleinstück, K. & Schulze, G. E. R. (1965). *Pendellösungs-Interferenzen mit thermischen Neutronen an Si-Einkristallen. Phys. Lett.* **14**, 174–175.

Sivardière, J. (1975). *Théorie dynamique de la diffraction magnétique des neutrons. Acta Cryst.* A**31**, 340–344.

Somenkov, V. A., Shil'shtein, S. Sh., Belova, N. E. & Utemisov, K. (1978). *Observation of dynamical oscillations for neutron scattering by Ge crystals using the inclination method. Solid State Commun.* **25**, 593–595.

Squires, G. L. (1978). *Introduction to the Theory of Thermal Neutron Scattering*. Cambridge University Press.

Stassis, C. & Oberteuffer, J. A. (1974). *Neutron diffraction by perfect crystals. Phys. Rev. B*, **10**, 5192–5202.

Takagi, S. (1962). *Dynamical theory of diffraction applicable to crystals with any kind of small distortion. Acta Cryst.* **15**, 1311–1312.

Takahashi, T., Tomimitsu, H., Ushigami, Y., Kikuta, S. & Doi, K. (1981). *The very-small angle neutron scattering from neutron-irradiated amorphous silica. Jpn. J. Appl. Phys.* **20**, L837–L839.

Takahashi, T., Tomimitsu, H., Ushigami, Y., Kikuta, S., Doi, K. & Hoshino, S. (1983). *The very-small angle neutron scattering from* SiO_2–PbO *glasses. Physica B*, **120**, 362–366.

Tasset, F. (1989). *Zero field neutron polarimetry. Physica B*, **156–157**, 627–630.

Taupin, D. (1964). *Théorie dynamique de la diffraction des rayons X par les cristaux déformés. Bull. Soc. Fr. Minéral. Cristallogr.* **87**, 469–511.

Tomimitsu, H. & Doi, K. (1974). *A neutron diffraction topographic observation of strain field in a hot-pressed germanium crystal. J. Appl. Cryst.* **7**, 59–64.

Tomimitsu, H., Doi, K. & Kamada, K. (1983). *Neutron diffraction topographic observation of substructures in Cu-based alloys. Physica B*, **120**, 96–102.

Tomimitsu, H., Takahashi, T., Kikuta, S. & Doi, K. (1986). *Very small angle neutron scattering from amorphous* $Fe_{78}B_{12}Si_{10}$. *J. Non-Cryst. Solids*, **88**, 388–394.

Tomimitsu, H. & Zeyen, C. (1978). *Neutron diffraction topographic observation of twinned silicon crystal. Jpn. J. Appl. Phys.* **3**, 591–592.

Werner, S. A. (1980). *Gravitational and magnetic field effects on the dynamical diffraction of neutrons. Phys. Rev. B*, **21**, 1774–1789.

Werner, S. A. (1995). *Neutron interferometry tests of quantum theory. Ann. NY Acad. Sci.* **755**, 241–262.

Werner, S. A., Staudenmann, J. L. & Colella, R. (1979). *The effect of the Earth's rotation on the quantum mechanical phase of the neutron. Phys. Rev. Lett.* **42**, 1103–1106.

Zachariasen, W. H. (1967). *A general theory of X-ray diffraction in crystals. Acta Cryst.* **23**, 558–564.

Zeilinger, A. (1995). Private communication.

Zeilinger, A. & Shull, C. G. (1979). *Magnetic field effects on dynamical diffraction of neutrons by perfect crystals. Phys. Rev. B*, **19**, 3957–3962.

Zeilinger, A., Shull, C. G., Horne, M. A. & Finkelstein, K. D. (1986). *Effective mass of neutrons diffracting in crystals. Phys. Rev. Lett.* **57**, 3089–3092.

Zelepukhin, M. V., Kvardakov, V. V., Somenkov, V. A. & Shil'shtein, S. Sh. (1989). *Observation of the Pendellösung fringe effect in magnetic scattering of neutrons. Sov. Phys. JETP*, **68**, 883–886.

Zolotoyabko, E. & Sander, B. (1995). *X-ray diffraction profiles in strained crystals undergoing ultrasonic excitation. The Laue case. Acta Cryst.* A**51**, 163–171.