### 1.5.11. Glossary

| | |
|---|---|
| $\alpha_{ij}$ | (linear) magnetoelectric tensor |
| $\beta_{ijk}$ | nonlinear magnetoelectric tensor *EHH* |
| $\gamma_{ijk}$ | nonlinear magnetoelectric tensor *HEE* |
| $\Delta$ | Weiss constant |
| $\Delta n$ | magnetic birefringence |
| $\varepsilon_{ij}$ | permittivity |
| $\lambda$ | constant describing magnetostriction |
| $\Lambda_{ijk}$ | tensor describing the piezomagnetic effect |
| $\Lambda_{i\alpha}$ | matrix describing the piezomagnetic effect |
| $\mu_{ij}$ | permeability |
| $\boldsymbol{\mu}$ | magnetic moment |
| $\mu_B$ | Bohr magneton |
| $\pi_{ijk\ell}$ | piezomagnetoelectric tensor |
| $\rho(\mathbf{r})$ | charge density |
| $\Phi$ | thermodynamic potential |
| $\chi^e_{ij}$ | dielectric susceptibility |
| $\chi_{ij}$, $\chi^m_{ij}$ | magnetic susceptibility |
| $\mathbf{B}$ | magnetic induction |
| $c$ | speed of light |
| $c_{ijk\ell}$ | elastic stiffness |
| $\mathrm{d}\tau$ | volume element |
| $e$ | charge of the electron |
| $\mathbf{E}$ | electric field |
| $g$ | Landé $g$-factor |
| $\mathbf{H}$ | magnetic field |
| $\mathbf{j}(\mathbf{r})$ | current density |
| $\mathbf{J}$ | total angular momentum |
| $J^{\mathrm{ex}}$ | exchange constant |
| $\mathbf{k}$ | position vector in reciprocal space |
| $k_B$ | Boltzmann factor |
| $\mathbf{l}_i$ | sum of the magnetic moments in a unit cell, in which some of the moments are taken with opposite sign |
| $\mathbf{L}_i$ | antiferromagnetic vector |
| $\mathbf{L}$ | orbital angular momentum (Section 1.5.1.1), antiferromagnetic vector (remainder of this chapter) |
| $\mathbf{m}(\mathbf{r})$ | magnetic moment density |
| $\mathbf{m}$ | sum of the magnetic moments in a unit cell |
| $\mathbf{M}$ | magnetization (= magnetic moment per unit volume = ferromagnetic vector) |
| $N$ | No. of atoms per unit volume |
| $p$ | effective number of Bohr magnetons (Section 1.5.1), pressure (remainder of this chapter) |
| $\mathbf{P}$ | electric polarization |
| $\mathbf{r}$ | position vector in space |
| $\mathbf{S}(\mathbf{r})$ | spin density |
| $\mathbf{S}$ | spin angular momentum (of an atom or ion) |
| $s_{ijk\ell}$ | elastic compliance |
| $S_{ij}$ | strain tensor |
| $T_{ij}$ | stress tensor |
| $T$ | temperature |
| $T_c$ | phase transition temperature |
| $T_C$ | Curie temperature |
| $T_N$ | Néel temperature |
| $U$ | energy |
| $U_a$ | anisotropy energy |
| $U_{\mathrm{el}}$ | elastic energy |
| $U_{\mathrm{me}}$ | magnetoelastic energy |
| $v$ | velocity |
| $Z$ | atomic number (= number of electrons per atom) |

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### References

Aizu, K. (1970). *Possible species of ferromagnetic, ferroelectric and ferroelastic crystals. Phys. Rev. B*, **2**, 754–772.

Akulov, N. (1928). *Über die Magnetostriktion der Eisenkristalle. Z. Phys.* **52**, 389–405.

Alcantara Bonfim, O. F. de & Gehring, G. A. (1980). *Magnetoelectric effect in antiferromagnetic crystals. Adv. Phys.* **29**, 731–769.

Anderson, J. C., Birss, R. R. & Scott, R. A. M. (1964). *Linear magnetostriction in hematite.* In *Proc. Int. Conf. Magnetism*, Nottingham, pp. 597–599. London: Institute of Physics and the Physical Society.

Andratskii, V. P. & Borovik-Romanov, A. S. (1966). *Piezomagnetic effect in $\alpha$-$Fe_2O_3$.* (In Russian.) *Zh. Eksp. Teor. Fiz.* **51**, 1030–1036. [English translation: *Sov. Phys. JETP*, **24** (1967), 687–691.]

Andreev, A. F. & Marchenko, V. I. (1976). *Macroscopic theory of spin waves.* (In Russian.) *Zh. Eksp. Teor. Fiz.* **70**, 1522–1538. (English translation: *Sov. Phys. JETP*, **43**, 794–803.)

Andreev, A. F. & Marchenko, V. I. (1980). *Symmetry and the macroscopic dynamics of magnetic materials.* (In Russian.) *Usp. Fiz. Nauk*, **130**, 39–63. (English translation: *Sov. Phys. Usp.* **23**, 21–34.)

Ascher, E. (1966). *Some properties of spontaneous currents. Helv. Phys. Acta*, **39**, 40–48.

Ascher, E. (1968). *Higher-order magneto-electric effects. Philos. Mag.* **17**, 149–157.

Ascher, E. (1970). *The interactions between magnetization and polarization: phenomenological symmetry considerations on boracites. J. Phys. Soc. Jpn*, **28** Suppl., 7–14.

Ascher, E., Rieder, H., Schmid, H. & Stössel, H. (1966). *Some properties of ferromagnetoelectric nickel–iodine boracite, $Ni_3B_7O_{13}I$. J. Appl. Phys.* **37**, 1404–1405.

Astrov, D. N. (1960). *The magnetoelectric effect in antiferromagnetics.* (In Russian.) *Zh. Eksp. Teor. Fiz.* **38**, 984–985. (English translation: *Sov. Phys. JETP*, **11**, 708–709.)

Astrov, D. N. (1961). *Magnetoelectric effect in chromium oxide.* (In Russian.) *Zh. Eksp. Teor. Fiz.* **40**, 1035–1041. (English translation: *Sov. Phys. JETP*, **13**, 729–733.)

Astrov, D. N., Al'shin, B. I., Zorin, R. V. & Drobyshev, L. A. (1968). *Spontaneous magnetoelectric effect.* (In Russian.) *Zh. Eksp. Teor. Fiz.* **55**, 2122–2127. [English translation: *Sov. Phys. JETP*, **28** (1969), 1123–1125.]

Barbara, B., Gignoux, D. & Vettier, C. (1988). *Lectures on Modern Magnetism.* Beijing: Science Press.

Bazhan, A. N. & Bazan, Ch. (1975). *Weak ferromagnetism in $CoF_2$ and $NiF_2$.* (In Russian.) *Zh. Eksp. Teor. Fiz.* **69**, 1768–1781. (English translation: *Sov. Phys. JETP*, **42**, 898–904.)

Becker, R. & Döring, W. (1939). *Ferromagnetismus.* Berlin: Springer.

Belov, N. V., Belova, E. N. & Tarkhova, T. N. (1964). *Polychromatic plane groups*. In Shubnikov & Belov (1964). *Colored Symmetry*, edited by W. T. Holser, pp. 228–237. Oxford: Pergamon.

Belov, N. V., Neronova, N. N. & Smirnova, T. S. (1957). *Shubnikov groups.* (In Russian.) *Kristallografiya*, **2**, 315–325. (English translation: *Sov. Phys. Crystallogr.* **2**, 311–322.)

Bertaut, E. F. (1963). *Spin configurations of ionic structures: theory and practice.* In *Magnetism*, Vol. III, edited by G. T. Rado & H. Suhl, pp. 149–209. New York: Academic Press.

Bertaut, E. F., Mercier, M. & Pauthenet, R. (1964). *Ordre magnétique et propriétés magnétiques de $MnYO_3$. J. Phys.* **25**, 550–557.

Bickford, L. R. Jr, Pappis, J. & Stull, J. L. (1955). *Magnetostriction and permeability of magnetite and cobalt-substituted magnetite. Phys. Rev.* **99**, 1210–1214.

Birss, R. R. (1964). *Symmetry and Magnetism.* Amsterdam: North-Holland.

Birss, R. R. & Anderson, J. C. (1963). *Linear magnetostriction in antiferromagnetics. Proc. Phys. Soc.* **81**, 1139–1140.

Bloembergen, N. (1962). In *Proc. Int. Conf. High Magnetic Fields*, edited by B. Lax, p. 454. New York: John Wiley.

Borovik-Romanov, A. S. (1959*a*). *Investigation of weak ferromagnetism in the $MnCO_3$ single crystal.* (In Russian.) *Zh. Eksp. Teor. Fiz.* **36**, 766–781. (English translation: *Sov. Phys. JETP*, **9**, 539–549.)