(2001)]. The determination of the tensor properties of all domain states is discussed in full in the book by Kopský (1982).

The relations between morphic properties, tensor parameters, order parameters and names of domain states are summarized in Table 3.4.2.4. Macroscopic principal domain states can be distinguished by various property tensors that transform either according to the same representation Γ_φ (tensors T and U) or different representations Γ_φ and Γ_σ (tensors T and S). In the microscopic description, a basic domain state may sometimes be shared by two physically different order parameters: a primary order parameter η (the order parameter, components of which form a quadratic invariant with a temperature-dependent coefficient in the free energy) and a pseudoproper order parameter ζ that transforms according to the same representation Γ_η as the primary order parameter but has a temperature coefficient that is almost independent of temperature. This is, however, rather rare (see, *e.g.*, Tolédano & Dmitriev, 1996).

3.4.2.4. *Synoptic table of ferroic transitions and domain states*

The considerations of this and all following sections can be applied to any phase transition with point-group symmetry descent $G \supset F$. All such non-magnetic *crystallographically non-equivalent symmetry descents* are listed in Table 3.4.2.7 together with some other data associated with symmetry reduction at a ferroic phase transition. These symmetry descents can also be traced in lattices of subgroups of crystallographic point groups, which are displayed in Figs. 3.1.3.1 and 3.1.3.2.

The symmetry descents $G \supset F_1$ listed in Table 3.4.2.7 are analogous to Aizu's '*species*' (Aizu, 1970*a*), in which the symbol F stands for the symbol $\supset$ in our symmetry descent, and the orientation of symmetry elements of the group F_1 with respect to G is specified by letters p, s, ps, pp *etc*. A list of 212 non-ferromagnetic species together with their property tensors is available online (Janovec, 2012).

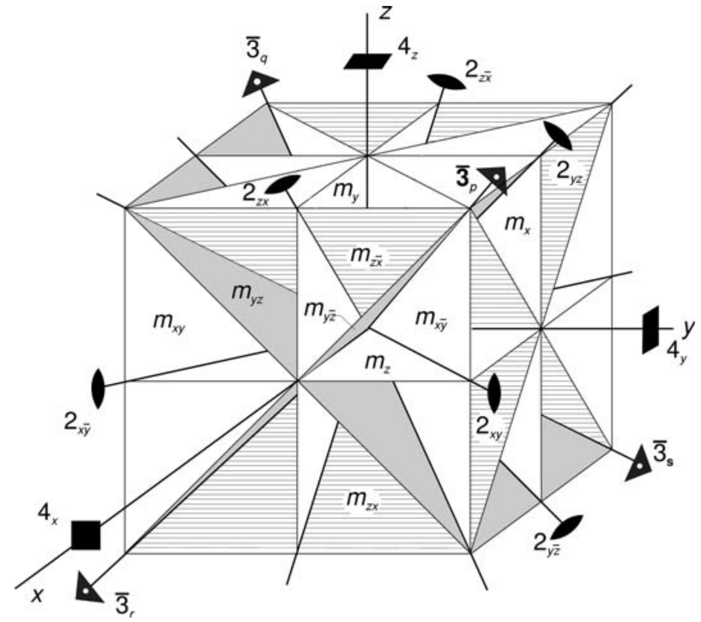

Fig. 3.4.2.3. Oriented symmetry operations of the cubic group $m\bar{3}m$ and of its subgroups. The Cartesian (rectangular) coordinate system x, y, z is identical with the crystallographic and crystallophysical coordinate systems. Correlation with other notations is given in Table 3.4.2.5.

As we have already stated, any systematic analysis of domain structures requires an unambiguous specification of the orientation and location of symmetry elements in space. Moreover, in a continuum approach, the description of crystal properties is performed in a rectangular (Cartesian) coordinate system, which

Table 3.4.2.5. *Symbols of symmetry operations of the point group* $m\bar{3}m$

Standard: symbols used in Section 3.1.3, in the present chapter and in the software; all symbols refer to the cubic crystallographic (Cartesian) basis, $p \equiv [111]$ (all positive), $q \equiv [\bar{1}\bar{1}1]$, $r \equiv [1\bar{1}\bar{1}]$, $s \equiv [\bar{1}1\bar{1}]$. BC: Bradley & Cracknell (1972). AH: Altmann & Herzig (1994). *IT* A: *IT* A (2005). Jones: Jones' faithful representation symbols express the action of a symmetry operation on a vector (xyz) (see *e.g.* Bradley & Cracknell, 1972).

Standard	BC	AH	*IT* A	Jones	Standard	BC	AH	*IT* A	Jones
1 or e	E	E	1	x, y, z	$\bar{1}$ or i	I	i	$\bar{1}$ 0, 0, 0	$\bar{x}, \bar{y}, \bar{z}$
2_z	C_{2z}	C_{2z}	2 $0, 0, z$	$\bar{x}, \bar{y}, z$	m_z	σ_z	σ_z	m $x, y, 0$	$x, y, \bar{z}$
2_x	C_{2x}	C_{2x}	2 $x, 0, 0$	$x, \bar{y}, \bar{z}$	m_x	σ_x	σ_x	m $0, y, z$	$\bar{x}, y, z$
2_y	C_{2y}	C_{2y}	2 $0, y, 0$	$\bar{x}, y, \bar{z}$	m_y	σ_y	σ_y	m $x, 0, z$	$x, \bar{y}, z$
2_{xy}	C_{2a}	C'_{2a}	2 $x, x, 0$	$y, x, \bar{z}$	m_{xy}	σ_{da}	σ_{d1}	m $x, \bar{x}, z$	$\bar{y}, \bar{x}, z$
$2_{x\bar{y}}$	C_{2b}	C'_{2b}	2 $x, \bar{x}, 0$	$\bar{y}, \bar{x}, \bar{z}$	$m_{x\bar{y}}$	σ_{db}	σ_{d2}	m x, x, z	y, x, z
2_{zx}	C_{2c}	C'_{2c}	2 $x, 0, x,$	$z, \bar{y}, x$	m_{zx}	σ_{dc}	σ_{d3}	m $\bar{x}, y, x,$	$\bar{z}, y, \bar{x}$
$2_{z\bar{x}}$	C_{2e}	C'_{2e}	2 $\bar{x}, 0, x$	$\bar{z}, \bar{y}, \bar{x}$	$m_{z\bar{x}}$	σ_{de}	σ_{d5}	m x, y, x	z, y, x
2_{yz}	C_{2d}	C'_{2d}	2 $0, y, y$	$\bar{x}, z, y$	m_{yz}	σ_{dd}	σ_{d4}	m $x, y, \bar{y}$	$x, \bar{z}, \bar{y}$
$2_{y\bar{z}}$	C_{2f}	C'_{2f}	2 $0, y, \bar{y}$	$\bar{x}, \bar{z}, \bar{y}$	$m_{y\bar{z}}$	σ_{df}	σ_{d6}	m x, y, y	x, z, y
3_p	C^+_{31}	C^+_{31}	3^+ x, x, x	z, x, y	$\bar{3}_p$	S^-_{61}	S^-_{61}	$\bar{3}^+$ x, x, x	$\bar{z}, \bar{x}, \bar{y}$
3_q	C^+_{32}	C^+_{32}	3^+ $\bar{x}, \bar{x}, x$	$\bar{z}, x, \bar{y}$	$\bar{3}_q$	S^-_{62}	S^-_{62}	$\bar{3}^+$ $\bar{x}, \bar{x}, x$	$z, \bar{x}, y$
3_r	C^+_{33}	C^+_{33}	3^+ $x, \bar{x}, \bar{x}$	$\bar{z}, \bar{x}, y$	$\bar{3}_r$	S^-_{63}	S^-_{63}	$\bar{3}^+$ $x, \bar{x}, \bar{x}$	$z, x, \bar{y}$
3_s	C^+_{34}	C^+_{34}	3^+ $\bar{x}, x, \bar{x}$	$z, \bar{x}, \bar{y}$	$\bar{3}_s$	S^-_{64}	S^-_{64}	$\bar{3}^+$ $\bar{x}, x, \bar{x}$	$\bar{z}, x, y$
3^2_p	C^-_{31}	C^-_{31}	3^- x, x, x	y, z, x	$\bar{3}^5_p$	S^+_{61}	S^+_{61}	$\bar{3}^-$ x, x, x	$\bar{y}, \bar{z}, \bar{x}$
3^2_q	C^-_{32}	C^-_{32}	3^- $\bar{x}, \bar{x}, x$	$y, \bar{z}, \bar{x}$	$\bar{3}^5_q$	S^+_{62}	S^+_{62}	$\bar{3}^-$ $\bar{x}, \bar{x}, x$	$\bar{y}, z, x$
3^2_r	C^-_{33}	C^-_{33}	3^- $x, \bar{x}, \bar{x}$	$\bar{y}, z, \bar{x}$	$\bar{3}^5_r$	S^+_{63}	S^+_{63}	$\bar{3}^-$ $x, \bar{x}, \bar{x}$	$y, \bar{z}, x$
3^2_s	C^-_{34}	C^-_{34}	3^- $\bar{x}, x, \bar{x}$	$\bar{y}, \bar{z}, x$	$\bar{3}^5_s$	S^+_{64}	S^+_{64}	$\bar{3}^-$ $\bar{x}, x, \bar{x}$	$y, z, \bar{x}$
4_z	C^+_{4z}	C^+_{4z}	4^+ $0, 0, z$	$\bar{y}, x, z$	$\bar{4}_z$	S^-_{4z}	S^-_{4z}	$\bar{4}^+$ $0, 0, z$	$y, \bar{x}, \bar{z}$
4_x	C^+_{4x}	C^+_{4x}	4^+ $x, 0, 0$	$x, \bar{z}, y$	$\bar{4}_x$	S^-_{4x}	S^-_{4x}	$\bar{4}^+$ $x, 0, 0$	$\bar{x}, z, \bar{y}$
4_y	C^+_{4y}	C^+_{4y}	4^+ $0, y, 0$	$z, y, \bar{x}$	$\bar{4}_y$	S^-_{4y}	S^-_{4y}	$\bar{4}^+$ $0, y, 0$	$\bar{z}, \bar{y}, x$
4^3_z	C^-_{4z}	C^-_{4z}	4^- $0, 0, z$	$y, \bar{x}, z$	$\bar{4}^3_z$	S^+_{4z}	S^+_{4z}	$\bar{4}^-$ $0, 0, z$	$\bar{y}, x, \bar{z}$
4^3_x	C^-_{4x}	C^-_{4x}	4^- $x, 0, 0$	$x, z, \bar{y}$	$\bar{4}^3_x$	S^+_{4x}	S^+_{4x}	$\bar{4}^-$ $x, 0, 0$	$\bar{x}, \bar{z}, y$
4^3_y	C^-_{4y}	C^-_{4y}	4^- $0, y, 0$	$\bar{z}, y, x$	$\bar{4}^3_y$	S^+_{4y}	S^+_{4y}	$\bar{4}^-$ $0, y, 0$	$z, \bar{y}, \bar{x}$

references