Table 4.1.2.1. *Location of additional symmetry element, if the translation vector* **t** *is perpendicular to the symmetry axis along* $0, 0, z$ *or to the symmetry plane in* $x, y, 0$

The symmetry centre at 0, 0, 0 is included. The table is restricted to integral translations (for centring translations, see Table 4.1.2.3). The symbol ⟲ indicates cyclic permutation.

Symmetry element at the origin	Translation vector **t**	Location of additional symmetry element	Representative plane and space groups (numbers)
$2, 2_1$	1, 0, 0 0, 1, 0 1, 1, 0	$\frac{1}{2}, 0, z$ $0, \frac{1}{2}, z$ $\frac{1}{2}, \frac{1}{2}, z$	$P2$ (3), $P2_1$ (4), $p2$ (2)
$3, 3_1, 3_2$	1, 0, 0 1, 1, 0	$\frac{2}{3}, \frac{1}{3}, z$ $\frac{1}{3}, \frac{2}{3}, z$	$P3$ (143)–$P3_2$ (145), $p3$ (13)
$4, 4_1, 4_2, 4_3$	1, 0, 0	$\frac{1}{2}, \frac{1}{2}, z$	$P4$ (75)–$P4_3$ (78), $p4$(10)
$6, 6_1, 6_2, 6_3, 6_4, 6_5$	–	–	$P6$ (168)–$P6_5$ (173), $p6$ (16)
m, *a*, *b*, *n*, *d*, *e*	0, 0, 1	$x, y, \frac{1}{2}$	*Pm* (6), *Pa*, *Pb*, *Pn* (7), *Fddd* (70), *Cmme* (67)
$\bar{1}$	1, 0, 0 ⟲ 1, 1, 0 ⟲ 1, 1, 1	$\frac{1}{2}, 0, 0$ ⟲ $\frac{1}{2}, \frac{1}{2}, 0$ ⟲ $\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$	$P\bar{1}$ (2)
$\bar{3}$	–	–	$P\bar{3}$ (147)
$\bar{4}$	0, 1, 0	$\frac{1}{2}, \frac{1}{2}, z$	$P\bar{4}$ (81)
$\bar{6}$	0, 1, 0 1, 1, 0	$\frac{1}{3}, \frac{2}{3}, z$ $\frac{2}{3}, \frac{1}{3}, z$	$P\bar{6}$ (174)

secondary symmetry elements in rhombohedral space groups (referred to rhombohedral axes). The middle part lists the twofold axes and symmetry planes that are secondary and tertiary symmetry elements in trigonal and hexagonal space groups and secondary symmetry elements in rhombohedral space groups (referred to hexagonal axes). The lower part illustrates the occurrence of threefold screw axes in rhombohedral and cubic space groups for the orientation [111].

Note that integral translations do not produce additional glide or screw components in triclinic, monoclinic and orthorhombic groups.

Example

The operation $(3/1, 0, 0)$ in a rhombohedral or cubic space group represents a screw rotation 3_1 with axis along [111]. Indeed, the third power of $(3/1, 0, 0)$ is the translation $t(1, 1, 1)$, *i.e.* the periodicity along the threefold axis. The translation $t(1, 0, 0)$ is decomposed uniquely into the screw component $\frac{1}{3}, \frac{1}{3}, \frac{1}{3}$ parallel to and the location component $\frac{2}{3}, -\frac{1}{3}, -\frac{1}{3}$ perpendicular to the threefold axis. The location of the 3_1 axis is then found to be $x, x+\frac{2}{3}, x+\frac{1}{3}$, which can also be expressed as $x+\frac{1}{3}, x, x+\frac{2}{3}$ or $x+\frac{2}{3}, x+\frac{1}{3}, x$.

For 2, *m* and *c*, the locations of the symmetry elements at the origin and within the cell can be interchanged.

Example

According to Table 4.1.2.2, the *c* plane located in *x, x, z* implies an *n* plane in $x, x+\frac{1}{2}, z$. *Vice versa*, an *n* plane in *x, x, z* implies a *c* plane in $x, x+\frac{1}{2}, z$.

In the rhombohedral space groups $R3c$ (161) and $R\bar{3}c$ (167) and in their cubic supergroups, diagonal *n* planes in *x, x, z* and, by symmetry, in *z, x, x* and *x, z, x* coexist with *c* planes in $x, x+\frac{1}{2}, z$, *a* planes in $z, x, x+\frac{1}{2}$ and *b* planes in $x+\frac{1}{2}, z, x$, respectively (*cf.* Section 4.3.5).

Note that *the symbol of a glide plane depends on the reference frame.* Thus, the above-mentioned *n* planes in the rhombohedral description become *c* planes in the hexagonal description of $R3c$ and $R\bar{3}c$; similarly, the *a, b* and *c* planes become *n* planes; *cf.* Sections 1.3.1 and 1.4.4.

4.1.2.2. *Centring translations**

The general rules given under (i) and (ii) remain valid. In lattices *C*, *A*, *B*, *I* and *F*, a centring vector **t** with a component parallel to the symmetry element leads to an additional symmetry element of a different kind. When the centring vector **t** is perpendicular to the symmetry element or when the symmetry element is an inversion centre or a rotoinversion axis, the additional symmetry element is of the same kind.

The first part of Table 4.1.2.3 contains pairs of *symmetry planes* related by a centring translation. Each box has three or four entries, which define three or four pairs of 'associated' planes; the cell under *F* contains all the planes under *C*, *A* and *B*. Hence, their locations are not repeated under *F*. Again, the locations of the two planes can be interchanged.

Example

The product of the *C*-centring translation, *i.e.* $t(\frac{1}{2}, \frac{1}{2}, 0)$, and the reflection through a mirror plane *m*, located in 0, *y*, *z*, is a glide reflection *b* with glide plane in $\frac{1}{4}, y, z$. Similarly, *C* centring associates a glide plane *c* in 0, *y*, *z* with a glide plane *n* in $\frac{1}{4}, y, z$.

Note that the mirror plane and 'associated' glide plane coincide geometrically when the centring translation is parallel to the mirror (*i.e.* no normal component exists); see the first cell under *A*, the second under *B*, the third cell under *C*. Also, two 'associated' glide planes (*a*, *b*) or (*b*, *c*) or (*a*, *c*) coincide geometrically. These 'double' glide planes are symbolized by '*e*'; see Table 4.1.2.3 and Section 1.3.2, Note (x).

* For the '*R* centring' see Section 4.3.5.