

1. TENSORIAL ASPECTS OF PHYSICAL PROPERTIES

1.1.4.8.2. Monoclinic system

1.1.4.8.2.1. Group 2

Choosing the twofold axis parallel to Ox_3 and applying the direct inspection method, one finds

$$\left(\begin{array}{ccc|cc|cc} & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \\ \bullet & \bullet & \bullet & & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \end{array} \right)$$

There are 13 independent components. If the twofold axis is parallel to Ox_2 , one finds

$$\left(\begin{array}{ccc|cc|cc} \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \end{array} \right)$$

1.1.4.8.2.2. Group m

One obtains the matrix representing the operator m by multiplying by -1 the coefficients of the matrix representing a twofold axis. The result of the reduction will then be exactly complementary: the components of the tensor which include an odd number of 3's are now equal to zero. One writes the result as follows:

$$\left(\begin{array}{ccc|cc|cc} \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \end{array} \right)$$

There are 14 independent components. If the mirror axis is normal to Ox_2 , one finds

$$\left(\begin{array}{ccc|cc|cc} \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \end{array} \right)$$

$$\left(\begin{array}{ccc|cc|cc} & & & \bullet & & & \\ & & & \bullet & & & \\ & & & \bullet & & & \\ \bullet & \bullet & \bullet & & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \end{array} \right)$$

There are 7 independent components.

1.1.4.8.3. Group mmm

All the components are equal to zero.

1.1.4.8.4. Trigonal system

1.1.4.8.4.1. Group 3

The threefold axis is parallel to Ox_3 . The matrix method should be used here. One finds

$$\left(\begin{array}{cccc|cc|cc} \bullet & \bullet \\ \bullet & \bullet \\ \bullet & \bullet \\ \bullet & \bullet \\ \bullet & \bullet \\ \bullet & \bullet \end{array} \right)$$

There are 9 independent components.

1.1.4.8.4.2. Group 32 with a twofold axis parallel to Ox_1

$$\left(\begin{array}{cc|cc|cc} \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \end{array} \right)$$

There are 4 independent components.

1.1.4.8.2.3. Group $2/m$

All the components are equal to zero.

1.1.4.8.4.3. Group 3m with a mirror normal to Ox_1

$$\left(\begin{array}{cc|cc|cc} \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet & \bullet & \bullet \end{array} \right)$$

There are 4 independent components.

1.1.4.8.3. Orthorhombic system

1.1.4.8.3.1. Group 222

There are three orthonormal twofold axes. The reduction is obtained by combining the results associated with two twofold axes, parallel to Ox_3 and Ox_2 , respectively.

$$\left(\begin{array}{ccc|cc|cc} & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \end{array} \right)$$

There are 6 independent components.

1.1.4.8.3.2. Group $mm2$

The reduction is obtained by combining the results associated with a twofold axis parallel to Ox_3 and with a mirror normal to Ox_2 :

$$\left(\begin{array}{cc|cc|cc} & & & \bullet & & & \\ & & & \bullet & & & \\ & & & \bullet & & & \\ \bullet & \bullet & \bullet & & \bullet & & \\ & & & \bullet & \bullet & & \\ & & & \bullet & \bullet & & \end{array} \right)$$

1.1.4.8.5. Tetragonal system

1.1.4.8.5.1. Group 4

The method of direct inspection can be applied for a fourfold axis. One finds