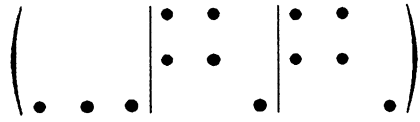


1. TENSORIAL ASPECTS OF PHYSICAL PROPERTIES

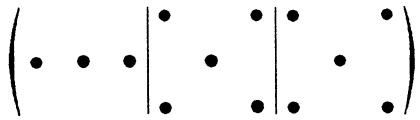
1.1.4.8.2. Monoclinic system

1.1.4.8.2.1. Group 2

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

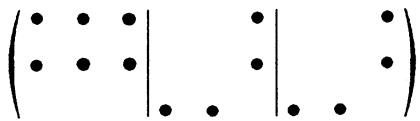


There are 13 independent components. If the twofold axis is parallel to  $Ox_2$ , one finds

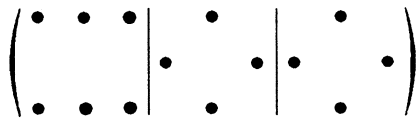


1.1.4.8.2.2. Group m

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:



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



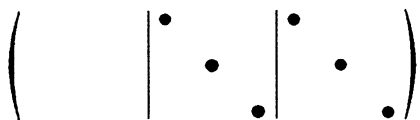
1.1.4.8.2.3. Group 2/m

All the components are equal to zero.

1.1.4.8.3. Orthorhombic system

1.1.4.8.3.1. Group 222

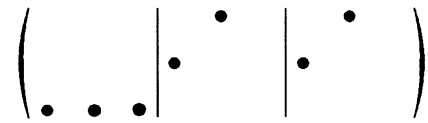
There are three orthonormal twofold axes. The reduction is obtained by combining the results associated with two twofold axes, parallel to  $Ox_3$  and  $Ox_2$ , respectively.



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  $Ox_2$ :



There are 7 independent components.

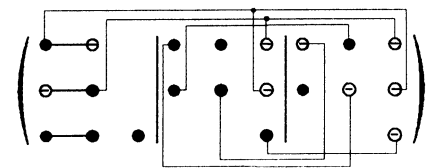
1.1.4.8.3.3. Group mmm

All the components are equal to zero.

1.1.4.8.4. Trigonal system

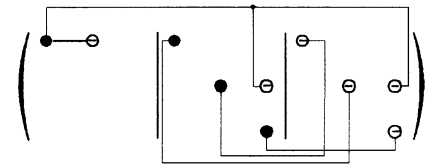
1.1.4.8.4.1. Group 3

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



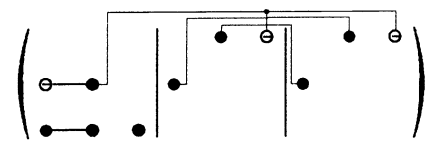
There are 9 independent components.

1.1.4.8.4.2. Group 32 with a twofold axis parallel to  $Ox_1$



There are 4 independent components.

1.1.4.8.4.3. Group 3m with a mirror normal to  $Ox_1$



There are 4 independent components.

1.1.4.8.4.4. Groups  $\bar{3}$  and  $\bar{3}m$

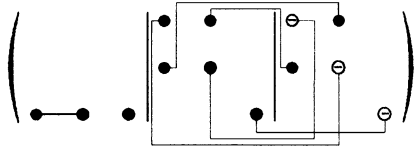
All the components are equal to zero.

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

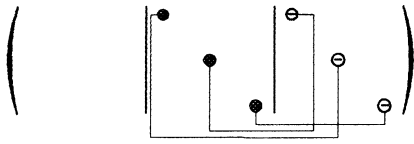
## 1.1. INTRODUCTION TO THE PROPERTIES OF TENSORS



There are 7 independent components.

### 1.1.4.8.5.2. Group 422

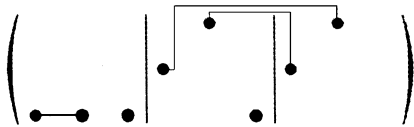
One combines the reductions for groups 4 and 222:



There are 3 independent components.

### 1.1.4.8.5.3. Group 4mm

One combines the reductions for groups 4 and 2m:



There are 4 independent components.

### 1.1.4.8.5.4. Group 4/m

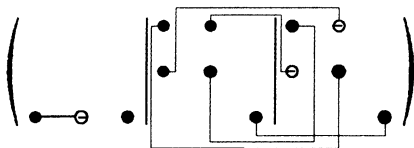
All the components are equal to zero.

### 1.1.4.8.5.5. Group $\bar{4}$

The matrix corresponding to axis  $\bar{4}$  is

$$\begin{pmatrix} 0 & \bar{1} & 0 \\ 1 & 0 & 0 \\ 0 & 0 & \bar{1} \end{pmatrix}$$

and the form of the  $3 \times 9$  matrix is

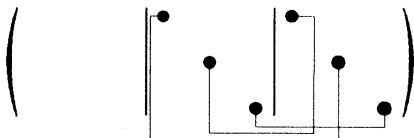


There are 6 independent components.

### 1.1.4.8.5.6. Group $\bar{4}2m$

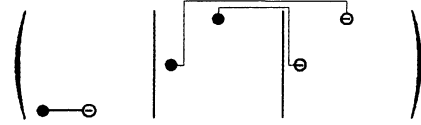
One combines either the reductions for groups  $\bar{4}$  and 222, or the reductions for groups 4 and 2mm.

(i) Twofold axis parallel to  $Ox_1$ :



There are 6 independent components.

(ii) Mirror perpendicular to  $Ox_1$  (the twofold axis is at  $45^\circ$ )



The number of independent components is of course the same, 6.

### 1.1.4.8.5.7. Group 4/m

All the components are equal to zero.

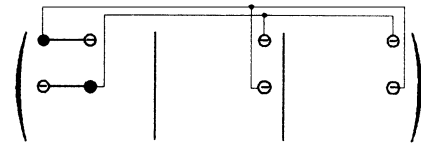
### 1.1.4.8.6. Hexagonal and cylindrical systems

#### 1.1.4.8.6.1. Groups 6, $A_\infty$ , 622, $A_\infty \infty A_2$ , 6mm and $A_\infty \infty M$

It was shown in Section 1.1.4.6.2.3 that, in the case of tensors of rank 3, the reduction is the same for axes of order 4, 6 or higher. The reduction will then be the same as for the tetragonal system.

#### 1.1.4.8.6.2. Group $\bar{6} = 3/m$

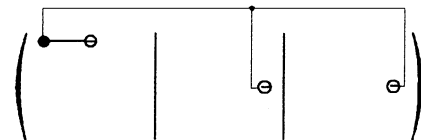
One combines the reductions for the groups corresponding to a threefold axis parallel to  $Ox_3$  and to a mirror perpendicular to  $Ox_3$ :



There are 2 independent components.

#### 1.1.4.8.6.3. Group $\bar{6}2m$

One combines the reductions for groups 6 and 2mm:



There is 1 independent component.

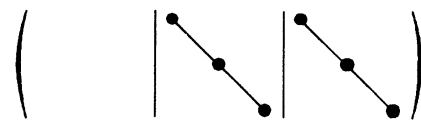
#### 1.1.4.8.6.4. Groups 6/m, $(A_\infty/M)C$ , 6/m and $(A_\infty/M) \infty (A_2/M)C$

All the components are equal to zero.

### 1.1.4.8.7. Cubic and spherical systems

#### 1.1.4.8.7.1. Group 23

One combines the reductions corresponding to a twofold axis parallel to  $Ox_3$  and to a threefold axis parallel to  $[111]$ :



There are 2 independent components.