

## 2. SYMMETRY ASPECTS OF EXCITATIONS

 Table 2.4.5.2. Cubic Laue classes  $C_1$  and  $C_2$ : longitudinal modes

This table, written for the class  $C_2$ , is also valid for the class  $C_1$  with the additional relation  $p_{12} = p_{13}$ . It can also be used for the spherical system where  $c_{44} = \frac{1}{2}(c_{11} - c_{12})$ ,  $p_{44} = \frac{1}{2}(p_{11} - p_{12})$ .

| $\hat{\mathbf{Q}} = \hat{\mathbf{u}}$ | $C$                                       | $\mathbf{e} = \mathbf{e}'$ | $\beta$                                       |
|---------------------------------------|---|----------------------------|---|
| (1, 0, 0)                             | $c_{11}$                                  | (0, 1, 0)                  | $p_{13}^2/c_{11}$                             |
| (1, 0, 0)                             | $c_{11}$                                  | (0, 0, 1)                  | $p_{12}^2/c_{11}$                             |
| (1, 1, 0)/ $\sqrt{2}$                 | $\frac{1}{2}(c_{11} + c_{12}) + c_{44}$   | (0, 0, 1)                  | $(p_{12} + p_{13})^2/4C$                      |
| (1, 1, 0)/ $\sqrt{2}$                 | $\frac{1}{2}(c_{11} + c_{12}) + c_{44}$   | (1, -1, 0)/ $\sqrt{2}$     | $(2p_{11} + p_{12} + p_{13} - 4p_{44})^2/16C$ |
| (1, 1, 1)/ $\sqrt{3}$                 | $\frac{1}{3}(c_{11} + 2c_{12} + 4c_{44})$ | (1, 1, -2)/ $\sqrt{6}$     | $(p_{11} + p_{12} + p_{13} - 2p_{44})^2/9C$   |
| (1, 1, 1)/ $\sqrt{3}$                 | $\frac{1}{3}(c_{11} + 2c_{12} + 4c_{44})$ | (1, -1, 0)/ $\sqrt{2}$     | $(p_{11} + p_{12} + p_{13} - 2p_{44})^2/9C$   |

 Table 2.4.5.3. Tetragonal  $T_1$  and hexagonal  $H_1$  Laue classes: longitudinal modes

This table, written for the class  $T_1$ , is also valid for the class  $H_1$  with the additional relations  $c_{66} = \frac{1}{2}(c_{11} - c_{12})$ ;  $p_{66} = \frac{1}{2}(p_{11} - p_{12})$ .

| $\hat{\mathbf{Q}} = \hat{\mathbf{u}}$ | $C$                                     | $\mathbf{e} = \mathbf{e}'$ | $\beta$                            |
|---------------------------------------|---|----------------------------|------------------------------------|
| (1, 0, 0)                             | $c_{11}$                                | (0, 1, 0)                  | $p_{12}^2/c_{11}$                  |
| (1, 0, 0)                             | $c_{11}$                                | (0, 0, 1)                  | $p_{31}^2/c_{11}$                  |
| (0, 0, 1)                             | $c_{33}$                                | (1, 0, 0)                  | $p_{13}^2/c_{33}$                  |
| (0, 0, 1)                             | $c_{33}$                                | (0, 1, 0)                  | $p_{13}^2/c_{33}$                  |
| (1, 1, 0)/ $\sqrt{2}$                 | $\frac{1}{2}(c_{11} + c_{12}) + c_{66}$ | (0, 0, 1)                  | $p_{31}^2/C$                       |
| (1, 1, 0)/ $\sqrt{2}$                 | $\frac{1}{2}(c_{11} + c_{12}) + c_{66}$ | (1, -1, 0)/ $\sqrt{2}$     | $(p_{11} + p_{12} - 2p_{66})^2/4C$ |

 Table 2.4.5.4. Hexagonal Laue class  $H_2$ : longitudinal modes

| $\hat{\mathbf{Q}} = \hat{\mathbf{u}}$ | $C$      | $\mathbf{e} = \mathbf{e}'$ | $\beta$           |
|---------------------------------------|----------|----------------------------|-------------------|
| (1, 0, 0)                             | $c_{11}$ | (0, 1, 0)                  | $p_{12}^2/c_{11}$ |
| (1, 0, 0)                             | $c_{11}$ | (0, 0, 1)                  | $p_{31}^2/c_{11}$ |
| (0, 0, 1)                             | $c_{33}$ | (1, 0, 0)                  | $p_{13}^2/c_{33}$ |
| (0, 0, 1)                             | $c_{33}$ | (0, 1, 0)                  | $p_{13}^2/c_{33}$ |
| (1, 1, 0)/ $\sqrt{2}$                 | $c_{11}$ | (0, 0, 1)                  | $p_{31}^2/c_{11}$ |
| (1, 1, 0)/ $\sqrt{2}$                 | $c_{11}$ | (1, -1, 0)/ $\sqrt{2}$     | $p_{12}^2/c_{11}$ |

 Table 2.4.5.5. Tetragonal Laue class  $T_2$ : longitudinal modes

| $\hat{\mathbf{Q}} = \hat{\mathbf{u}}$ | $C$      | $\mathbf{e} = \mathbf{e}'$ | $\beta$           |
|---------------------------------------|----------|----------------------------|-------------------|
| (0, 0, 1)                             | $c_{33}$ | (1, 0, 0)                  | $p_{13}^2/c_{33}$ |
| (0, 0, 1)                             | $c_{33}$ | (0, 1, 0)                  | $p_{13}^2/c_{33}$ |

 Table 2.4.5.6. Orthorhombic Laue class  $O$ : longitudinal modes

| $\hat{\mathbf{Q}} = \hat{\mathbf{u}}$ | $C$      | $\mathbf{e} = \mathbf{e}'$ | $\beta$           |
|---------------------------------------|----------|----------------------------|-------------------|
| (1, 0, 0)                             | $c_{11}$ | (0, 1, 0)                  | $p_{21}^2/c_{11}$ |
| (1, 0, 0)                             | $c_{11}$ | (0, 0, 1)                  | $p_{31}^2/c_{11}$ |
| (0, 1, 0)                             | $c_{22}$ | (0, 0, 1)                  | $p_{32}^2/c_{22}$ |
| (0, 1, 0)                             | $c_{22}$ | (1, 0, 0)                  | $p_{12}^2/c_{22}$ |
| (0, 0, 1)                             | $c_{33}$ | (1, 0, 0)                  | $p_{13}^2/c_{33}$ |
| (0, 0, 1)                             | $c_{33}$ | (0, 1, 0)                  | $p_{23}^2/c_{33}$ |

 Table 2.4.5.7. Trigonal Laue class  $R_1$ : longitudinal modes

| $\hat{\mathbf{Q}} = \hat{\mathbf{u}}$ | $C$      | $\mathbf{e}$ | $\mathbf{e}'$ | $\beta$           |
|---------------------------------------|----------|--------------|---------------|-------------------|
| (1, 0, 0)                             | $c_{11}$ | (0, 1, 0)    | (0, 1, 0)     | $p_{12}^2/c_{11}$ |
| (1, 0, 0)                             | $c_{11}$ | (0, 0, 1)    | (0, 0, 1)     | $p_{31}^2/c_{11}$ |
| (1, 0, 0)                             | $c_{11}$ | (0, 1, 0)    | (0, 0, 1)     | $p_{41}^2/c_{11}$ |
| (0, 0, 1)                             | $c_{33}$ | (1, 0, 0)    | (1, 0, 0)     | $p_{13}^2/c_{33}$ |
| (0, 0, 1)                             | $c_{33}$ | (0, 1, 0)    | (0, 1, 0)     | $p_{13}^2/c_{33}$ |

 Table 2.4.5.8. Trigonal Laue class  $R_2$ : longitudinal modes

| $\hat{\mathbf{Q}} = \hat{\mathbf{u}}$ | $C$      | $\mathbf{e}$ | $\mathbf{e}'$ | $\beta$           |
|---------------------------------------|----------|--------------|---------------|-------------------|
| (0, 0, 1)                             | $c_{33}$ | (1, 0, 0)    | (1, 0, 0)     | $p_{13}^2/c_{33}$ |
| (0, 0, 1)                             | $c_{33}$ | (0, 1, 0)    | (0, 1, 0)     | $p_{13}^2/c_{33}$ |

resolutions are required, one uses a spherical interferometer as described below.

A major limitation of the Fabry–Perot interferometer is its poor contrast, namely the ratio between the maximum and the minimum of the Airy function, which is typically  $\sim 1000$ . This limits the use of this instrument to samples of very high optical quality, as otherwise the generally weak Brillouin signals are masked by the elastically scattered light. To avert this effect, several passes are made through the same instrument, thus elevating the Airy function to the corresponding power (Hariharan & Sen, 1961; Sandercock, 1971). Multiple-pass instruments with three, four or five passes are common. Another limitation of the standard Fabry–Perot interferometer is that the interference pattern is repeated at each order. Hence, if the spectrum has a broad spectral spread, the overlap of adjacent orders can greatly complicate the interpretation of measurements. In this case, tandem instruments can be of considerable help. They consist of two Fabry–Perot interferometers with combs of different periods placed in series (Chantrel, 1959; Mach *et al.*, 1963). These are operated around a position where the peak transmission of the first interferometer coincides with that of the second one. The two Fabry–Perot interferometers are scanned simultaneously. With this setup, the successive orders are reduced to small ghosts and overlap is not a problem. A convenient commercial instrument has been designed by Sandercock (1982).

To achieve higher resolutions, one uses the spherical Fabry–Perot interferometer (Connes, 1958; Hercher, 1968). This consists

of two spherical mirrors placed in a near-confocal configuration. Their spacing  $\ell$  is scanned over a distance of the order of  $\lambda$ . The peculiarity of this instrument is that its luminosity increases with its resolution. One obvious drawback is that a change of resolving power, *i.e.* of  $\ell$ , requires other mirrors. Of course, the single spherical Fabry–Perot interferometer suffers the same limitations regarding contrast and order overlap that were discussed above for the planar case. Multipassing the spherical Fabry–Perot interferometer is possible but not very convenient. It is preferable to use tandem instruments that combine a multipass planar instrument of low resolution followed by a spherical instrument of high resolution (Pine, 1972; Vacher, 1972). To analyse the linewidth of narrow phonon lines, the planar standard is adjusted dynamically to transmit the Brillouin line and the spherical interferometer is scanned across the line. With such a device, resolving powers of  $\sim 10^8$  have been achieved. For the dynamical adjustment of this instrument one can use a reference signal near the frequency of the phonon line, which is derived by electro-optic modulation of the exciting laser (Sussner & Vacher, 1979). In this case, not only the width of the phonon, but also its absolute frequency shift, can be determined with an accuracy of  $\sim 1$  MHz. It is obvious that to achieve this kind of resolution, the laser source itself must be appropriately stabilized.

In closing, it should be stressed that the practice of interferometry is still an art that requires suitable skills and training in spite of the availability of commercial instruments. The experimenter must take care of a large number of aspects relating to the