where $\hat{K}$ describes the propagation direction and $K = 2\pi/\Lambda = \Omega/v_a$ is the propagation constant with v_a being the acoustic velocity. A *standing* plane acoustic wave is a combination of two contrapropagating traveling waves of equal amplitude, wavelength, and frequency:

$$\mathbf{u}(\mathbf{r}, t) = \boldsymbol{\mathcal{U}} \cos(\mathbf{K} \cdot \mathbf{r}) \cos \Omega t. \tag{2.80}$$

An acoustic wave polarized in the direction of $\mathbf{K}$ is known as a *longitudinal wave*, while one with a polarization perpendicular to $\mathbf{K}$ is called a *transverse wave*. For any given direction of propagation in a medium, there are *three* orthogonal acoustic normal modes of polarization: one longitudinal or quasi-longitudinal mode, and two transverse or quasi-transverse modes.

The mechanical strains associated with deformation are described by a symmetric *strain tensor*, $\mathbf{S} = [S_{ij}]$, defined by

$$S_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right), \tag{2.81}$$

where the indices $i, j = x, y, z$. The three tensor elements S_{xx}, S_{yy}, and S_{zz} are *tensile strains*, while the other elements $S_{yz} = S_{zy}$, $S_{zx} = S_{xz}$, and $S_{xy} = S_{yx}$ are *shear strains*. In addition, there is an antisymmetric *rotation tensor*, $\mathbf{R} = [R_{ij}]$, defined by

$$R_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} - \frac{\partial u_j}{\partial x_i}\right). \tag{2.82}$$

Clearly, $R_{xx} = R_{yy} = R_{zz} = 0$, while $R_{yz} = -R_{zy}$, $R_{zx} = -R_{xz}$, and $R_{xy} = -R_{yx}$. For elastic deformation caused by an acoustic wave, all of the strain and rotation tensor elements are space- and time-dependent quantities.

Mechanical strain in a medium causes changes in the optical property of the medium due to the *photoelastic effect*. The basis of acousto-optic interaction is the *dynamic photoelastic effect* in which the periodic time-dependent mechanical strain and rotation caused by an acoustic wave induce periodic time-dependent variations in the optical properties of the medium. The photoelastic effect is traditionally defined in terms of changes in the elements of the relative impermeability tensor:

$$\eta_{ij}(\mathbf{S}, \mathbf{R}) = \eta_{ij} + \Delta\eta_{ij}(\mathbf{S}, \mathbf{R}) = \eta_{ij} + \sum_{k,l}\left(p_{ijkl}S_{kl} + p'_{ijkl}R_{kl}\right), \tag{2.83}$$

where p_{ijkl} are dimensionless *elasto-optic coefficients*, also called *strain-optic coefficients* or *photoelastic coefficients*, and p'_{ijkl} are dimensionless *rotation-optic coefficients*. Both are fourth-order tensors. Because $\eta_{ij} = \eta_{ji}$ and $S_{kl} = S_{lk}$, the $[p_{ijkl}]$ tensor is symmetric in i and j and in k and l. Because $\eta_{ij} = \eta_{ji}$ and $R_{kl} = -R_{lk}$, the $[p'_{ijkl}]$ tensor is symmetric in i and j but is antisymmetric in k and l.

The photoelastic effect exists in all matter, including centrosymmetric crystals and isotropic materials, because the $[p_{ijkl}]$ tensor never vanishes in any material though the $[p'_{ijkl}]$ tensor vanishes in isotropic materials and cubic crystals. *Acousto-optic interactions are not precluded by any symmetry property of a material.* The tensor form of $[p_{ijkl}]$ for a crystal is determined by the point group of the crystal. The $[p'_{ijkl}]$ tensor elements of a crystal are determined by the birefringence of the crystal. If the indices i, j, k, ~~are~~ l referenced to the principal axes of a crystal, we have