

3.012 Fund of Mat Sci: Structure – Lecture 20

SYMMETRIES AND TENSORS

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Einstein explaining the Einstein convention

Homework for Mon Nov 28

- Study: 3.3 Allen-Thomas (Symmetry constraints)
- Read all of Chapter 1 Allen-Thomas

Last time:

1. Atoms as spherical scatterers
2. Huygens construction \rightarrow Laue condition
3. Ewald construction
4. Debye-Scherrer experiments

Scalars, vectors, tensors

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$$j_1 = \sigma_{11}E_1 + \sigma_{12}E_2 + \sigma_{13}E_3$$

$$j_2 = \sigma_{21}E_1 + \sigma_{22}E_2 + \sigma_{23}E_3$$

$$j_3 = \sigma_{31}E_1 + \sigma_{32}E_2 + \sigma_{33}E_3$$

Einstein's convention

Transformation of a vector

Transformation of a vector

Orthogonal Matrices

Transformation of a tensor

Transformation law for products of coordinates

Neumann's principle

- *the symmetry elements of any physical property of a crystal must include all the symmetry elements of the point group of the crystal*

Symmetry constraints

- Determine the crystallographic point group
- Choose a generator group (set of symmetry operation which fully generates the complete point group symmetry)
- Transform all components of a tensor by each of the symmetry elements
- Impose Neumann's principle that a tensor component and its transformed remain identical for a symmetry operation

Symmetry constraints

Symmetry constraints

Scalar, vector, tensor properties

- Mass (0), polarization (1), strain (2)

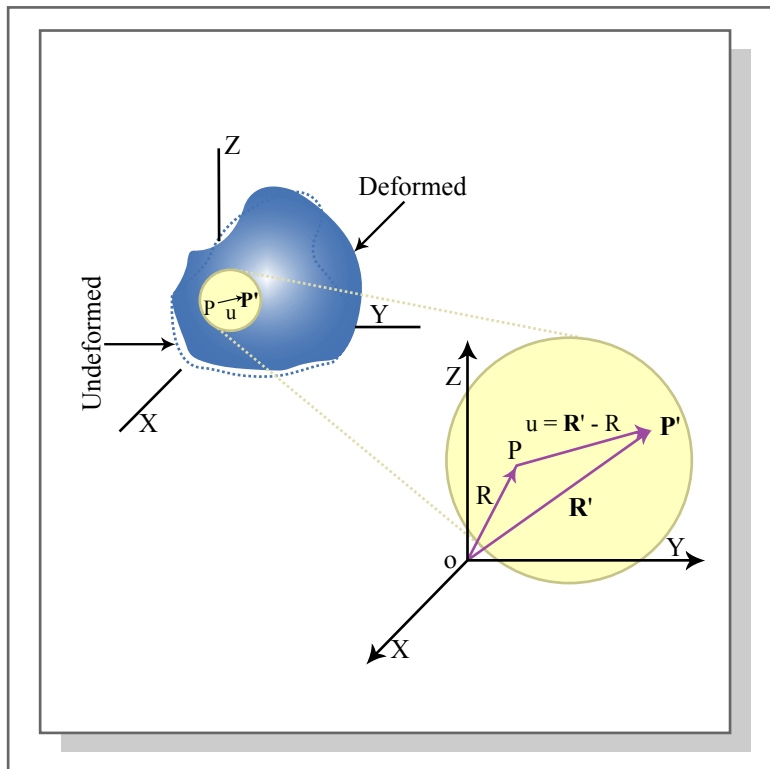


Figure by MIT OCW.

$$\epsilon_{ij} = \frac{1}{2} \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right)$$

Physical properties and their relation to symmetry

- Density (mass, from a certain volume)
- Pyroelectricity (polarization from temperature)
- Conductivity (current, from electric field)
- Piezoelectricity (polarization, from stress)
- Stiffness (strain, from stress)

Curie's Principle

- *a crystal under an external influence will exhibit only those symmetry elements that are common to both the crystal and the perturbin influence*