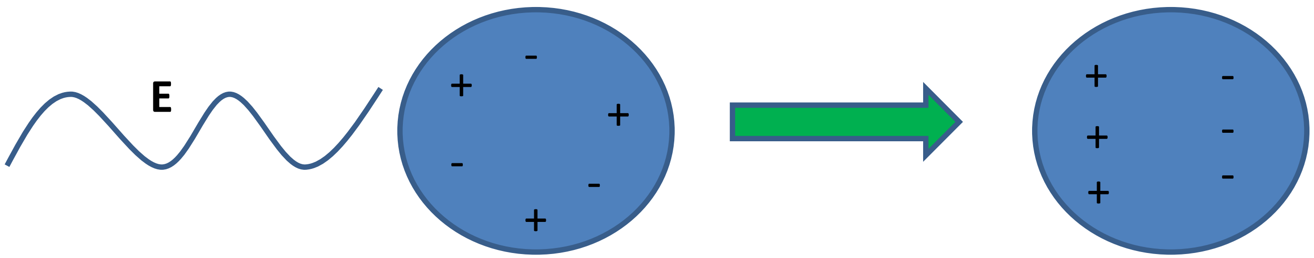
Origin of $\mathbf{P} = \chi^{(1)}\,\mathbf{E}$

$$\mathbf{P} = \mathbf{P}^{\text{oreintation}} + \mathbf{P}^{\text{induced}}$$

$$= N\,\frac{\mu^2}{3kT}\,\mathbf{E} \quad + N\alpha\mathbf{E}$$



- If **E** is small then the displacement of these electrons is periodical and can be modeled with a harmonic oscillator

- When large electric field is used, then the situation becomes similar to anharmonic oscillator and we cannot express polarization in a linear manner. Hence, it is expressed as power series.

$$\mathbf{P = \chi^{(1)}\, E + \chi^{(2)}\, E^2 + \chi^{(3)}\, E^3 + \ldots\ldots}$$

χ is a complex quantity and contains important information about dielectric medium. Real part contains information about refractive index and imaginary part contains information about absorption coefficient.

- Since χ is a tensorial quantity we rewrite equation as,

$$\mathbf{P} = \boldsymbol{\chi}^{(1)}{}_{ij}\, \mathbf{E}_j + \boldsymbol{\chi}^{(2)}{}_{ijk}\, \mathbf{E}_j\, \mathbf{E}_k + \boldsymbol{\chi}^{(3)}{}_{ijkl}\, \mathbf{E}_j \mathbf{E}_k \mathbf{E}_l + \ldots\ldots$$

- Under linear regime superposition principle is followed.

Examples of NLO

- **Refractive Index (n)**
  - When electric field strength is small, refractive index (n) remains nearly constant. For very large electric field refractive index varies with square of electric field

$$n \propto \mathbf{E}^2$$

- **Absorption coefficient**
  - When electric field is small Lambert – Beer law stays valid and as electric field reaches high then Lambert Beer law does not hold good.