Dispersion in dense matter

in gas: large separation → induced dipole fields don't overlap.

— limit of $1/R^2$, $1/R^3$ terms.

liquids/solids

atoms/molecules are subjected to $E_{app} + E_{neighbors} \equiv \vec{E}_{mol}$

induced dipole:

$$\vec{p} = \alpha \vec{E}_{mol} \qquad \alpha = \text{polarizability}$$

$\vec{P} = N\vec{p}$ still, so $N\alpha = \chi_e$

the macroscopic $\vec{E}$ is connected to microscopic by:

$$\vec{E} = \vec{E}_{mol} + \vec{E}_{self}$$

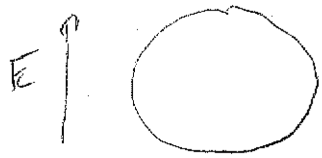
models: (ref. pack 10-14)

1) place dipole in hollow cavity in a dielectric

$$\rightarrow \quad \vec{E}_{cav}(\vec{p}) = \frac{2(\varepsilon-1)}{2\varepsilon+1}\frac{\vec{p}}{a^3}$$

field in cavity from bound charges on inside surface.

2) apply field $\vec{E}$ onto hollow sphere



$$\vec{E}_{cav}(\vec{E}) = \frac{3\varepsilon}{2\varepsilon+1}\vec{E}$$

dipole induced is

$$\vec{p} = \alpha \underbrace{\left(\vec{E}_{cav}(\vec{p}) + \vec{E}_{cav}(\vec{E})\right)}_{\vec{E}_{mol}}$$

since $\vec{D} = \vec{E} + 4\pi\vec{P} \equiv \varepsilon\vec{E}$

$$\vec{P} = \frac{\varepsilon-1}{4\pi}\vec{E} \quad \text{and} = N\vec{p}$$

write $\vec{E}_{cav}(\vec{p})$ as $\frac{2(\varepsilon-1)}{2\varepsilon+1} \cdot \frac{1}{a^3} \frac{\varepsilon-1}{4\pi N} \vec{E}$

now have $\vec{p} = \alpha(\omega)\vec{E}$

$\rightarrow \quad 4\pi N\vec{p} = (\varepsilon-1)\vec{E}$

gives relation:

$$\frac{4\pi}{3} N\alpha = \frac{(\varepsilon-1)(2\varepsilon+1)}{9\varepsilon + \frac{3(\varepsilon-1)^2}{2\pi N a^3}}$$ Böttcher's formula,

if $a^3 = \frac{3}{8\pi} \cdot \frac{1}{N} \rightarrow \frac{4\pi}{3} N\alpha = \frac{\varepsilon-1}{\varepsilon+2}$ Cl.-Moss.

$$= \frac{n^2-1}{n^2+2}.$$

describes density variation of n well,

e.g. gas $\rightarrow$ liquid

can tweak value of a^3 to get better agreement.