PROBLEMS

Lecture 1

1. Consider an optic mode in a cubic ionic crystal in external magnetic field $\mathbf{H}$. Find how the spectrum of optic phonons changes due to magnetic field.

2. Consider a square lattice of identical atoms, interacting via potentials, dependent on distances between nearest neighbors. Find spectra of normal modes and spectral density of states

$$g(\omega) = \sum_{s=1}^{3} \int_{BZ} (d\mathbf{q}) \delta(\omega - \omega_s(\mathbf{q})); \quad (d\mathbf{q}) = \frac{d^2 q}{(2\pi)^2}.$$

   Notice singularities of $g(\omega)$ and connect them with the saddle points of dispersion laws.

3. Take into account the effect of long ranged Coulomb interaction on spectra of optic phonons (polarization fluctuations) in a cubic ionic crystal. Find connection between the longitudinal-transverse mode splitting and static dielectric constant (Lydden-Sachs-Teller relation). Repeat this analysis for a uni-axial crystal.

4. Discuss the spectra of acoustic phonons in layered crystal and temperature dependence of their specific heat and thermal expansion.

5. The crystals without inversion centers have piezo-effect. This leads to the following extra term in the free energy

of isotropic medium:

$$F_P = d e_{\alpha\beta\gamma} P_\alpha u_{\beta\gamma},$$

where $\mathbf{P}$ is polarization and $u_{\beta\gamma}$ is the strain tensor. Find spectra of optic modes at small wave vectors.
Find also spectra in a uni-axial crystal, where

$$F_P = d P_z u_{xy},$$

6. Consider Raman scattering of light by optic phonons. Find the cross-section. If the crystal has inversion center what may be said about contribution of optic modes to scattering (absorption).