PROBLEMS

Lecture 5

1. Graphite has a layered structure. Carbon atoms in every layer are forming a hexagonal lattice. Electron band spectrum of a single plane is that of a gap-less semiconductor with six Dirac-like crossing points, located at M-point at the boundaries of the Brillouin Zone. The next layer is shifted with respect of the previous one. So, every carbon atom sees tree other above itself and tree more below and forms perfect triangles. Hybridization between the plane is weak, compare to that in the plane. Find electron spectra and draw the Fermi-surfaces for graphite.

2. Effective Hamiltonian for hole in the valence band of cubic semiconductors has the following form (*J.Luttinger*):

$$\hat{\mathcal{H}} = A\mathbf{p}^2 + B(\hat{\mathbf{J}} \cdot \mathbf{p})^2 + C(\hat{J}_x^2 p_x^2 + \hat{J}_y^2 p_y^2 + \hat{J}_z^2 p_z^2), \qquad (1)$$

   where C is a parameter, resposible for anysotropy. Draw schematically the surfaces of equal energy (in basic plane $< 100 >$, in diagonal plane $< 110 >$).
   Consider cyclotron resonance on holes in cubic semiconductors. Show that both "heavy" and "light" frequencies depend on orientation of magnetic field with respect to crystallographic axes.

3. Recombination of excitations in a heterostructure is caused by tunneling of electrons and holes towards each other. Assuming that both sides of heterostructure are presented by

a cubic semiconductor, show that light, emitted in direction parallel to the heterostructure plane, is polarized and find degree of polarization.

4. Develop theory of effective mass and apply it to the problem of ground states of shallow donor and shallow acceptor in cubic semiconductors.

5. Find splitting of the ground state of a donor in many valley cubic semiconductors (Ge, Si, $AlAs$)?

6. Find the g-factor of 2D holes for direction of magnetic field, parallel to inversion layer on (111) facet of Si.

7. Show that illumination of a cubic semiconductor by a circularly polarized light creates spin polarized electrons. Find degree of their polarization and its dependence on light frequency.