Homework #7, PHY 674, 25 October 1995

(X31). Most elemental (group IV) and compound (III-V and II-VI) semiconductors crystallize in three different crystal structures: In the diamond structure (with point group $O_h = O \times i$), the zincblende structure (with point group T_d), and the Wurtzite structure (with point group C_{6v}). Find how electronic states with angular momentum quantum numbers $l = 0, 1, 2, 3, 4$ split under the crystal field for each of the three crystal structures. (4 points)

(X32). Determine the crystal field splittings for electrons with angular momentum quantum numbers $l = 0, 1, 2, 3, 4$ in the high-temperature superconductor $YBa_2Cu_3O_7$ with orthorhombic point group $D_{2h} = D_2 \times i$. Do the same for the tetragonal compound $YBa_2Cu_3O_6$ with point group $D_{4h} = D_4 \times i$. (4 points)

(X33). Find how the $2j + 1$-fold degenerate states of an electron with spin quantum number s=1/2 and total angular momentum j=1/2,3/2,5/2,7/2,9/2 split in a cubic field of symmetry O (4 points). Hint: Use the double-group character table in Joshua (p. 76) or Tinkham (p. 77).

(X34). Find the double groups, classes, and "extra" irreducible representations for the point groups O_h and T_d.

(X35). Find the double groups, classes, and "extra" irreducible representations for the point groups D_{2h} and D_{4h}.

(X36). Find how the $2j + 1$-fold degenerate states of an electron with spin quantum number s=1/2 and total angular momentum j=1/2,3/2,5/2,7/2,9/2 split in a field of symmetry O_h, T_d, D_{2h}, D_{4h}.

For the cubic groups, use the notation and character tables from Bouckaert, Smoluchowksi, and Wigner, Phys. Rev. **50**, 58 (1936). (Otherwise, your results will not help you to read semiconductor band structures.) For D_{2h} and D_{4h}, use the notation from Tinkham and the subscripts g (gerade) and u (ungerade) for even and odd representations.

All problems are worth 4 points each. Some of them may require a large amount of calculations, so budget your time and do the problems that you are most interested in.

Due Date:
Wednesday, 01 November 1995, 2:10 pm
in the green box in Room 12 (or in class).

Dr. Stefan Zollner, A205 Physics, 294-7327, 24 October 1995.
Send questions to: zollner@iastate.edu