Universität Bielefeld	Symmetrien in der Physik	Prof. Dr. Jürgen Schnack
Fakultät für Physik	WS 2014/2015	jschnack@uni-bielefeld.de

Problem sheet 14

14.1 Dipole selection rules

Please read the text on electric dipole selection rules by Prof. Michael Romalis (Princeton) which is available in stud.ip.

a. The Wigner- Eckart theorem tells you immediately which matrix elements of the electric dipole operator are bound to be zero since the related Clebsch-Gordan coefficients are zero. But the reduced matrix element can also be zero. In the case of the electric dipole operator this leads to further restrictions of transitions between single-electron states $|\, l, m_l \,\rangle$. How do the complete selection rules look like and which mathematical object leads to the further restriction?

b. We consider states which describe the coupling to the electronic spin, i.e. single-electron states of the form $|\, l, s, j, m_j \,\rangle$. Calculate the selection rules for j with the help of eqs. (15) and (16) in the text.

14.2 Branching ratios

If an initial state can decay into several final states by means of a transition operator, this is called *branching* and the ratios of the intensities *branching ratios*. Often such ratios are fully determined by Clebsch-Gordan coefficients.
The intensity is proportional to the absolute square of the transition matrix elements.

a. Calculate the branching ratios for the spontaneous decay of the state $|\, n = 3, l = 2, m_l = 0 \,\rangle$ by means of dipole radiation. First consider into how many and which states the initial state can decay.

b. In the good old times, when scientists enjoyed paper and pencil, branching ratios were calculated with clever group theory and heavy usage of the Wigner-Eckart theorem. For your amusement read the article by D. Zeppenfeld, *SU(3) Relations for B-Meson Decays*, Z. Phys. C **8**, 77 (1981). Before you faint, forward to section II. Although you probably do not understand anything of the B meson physics you should enjoy the text and understand its technicalities: the involved particles are arranged in multiplets of a Lie group. They transform like the irreducible basis function of this group with the same quantum numbers. The transition operator is a well expressed in this form. Then everything follows from the Wigner-Eckart theorem with fancy Clebsch-Gordan coefficients.