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— Theoretical Atomic Physics —

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Summer Term

Home Work (4)

Task 16: Isotope shift in lithium

Estimate the normal mass shift of the $2s - 2p$ transition in Lithium for the two isotopes ^{6}Li and ^{7}Li. Use the experimentally available transition energy, for your estimate.

Task 17: Spin-orbit coupling

Calculate the expectation value of the spin-orbit coupling Hamiltonian

$$H_{\rm LS} = \frac{\mu_B}{c^2} \frac{1}{r} \frac{\partial V}{\partial r} \boldsymbol{L} \cdot \boldsymbol{S}$$

for the eigenstates of a hydrogen-like atom.

Hint: You can use

$$\langle r^{-1} \rangle = \frac{1}{n^2} \qquad\qquad \langle r^{-2} \rangle = \frac{1}{\left(l + \frac{1}{2}\right) n^3 a^2}$$

where $a = a_0/Z$, as well as Kramer's relation:

$$\frac{a^2 s}{4} \left((2\ell + 1)^2 - s^2 \right) \langle r^{s-2} \rangle - a \, (2s + 1) \, \langle r^{s-1} \rangle + \frac{s + 1}{n^2} \, \langle r^s \rangle = 0$$

Task 19: Angular Momentum coupling (2)

a) Prove that only three terms (^{1}S, ^{1}D, ^{3}P) are allowed for the ground-state configuration $1s^2 2s^2 2p^2$ of a carbon-like system. Work in LS-coupling.

b) Find all terms, which are possible for the electronic configuration d^2.

c) Couple the two valence shells to the electronic configuration $p^2 d^2$

Task 18: Relativistic angular momentum coupling

List the possible terms $(n_1 j_1, n_2 j_2, \dots)$ and total angular momentum J in jj-coupling for the following electronic configurations:

a) $1s^2$

b) 1s2s

c) $1s^2 2s^2 2p$

d) $1s^2 2s^2 2p^5$

e) ns n′p

f) np n′d