Quantum Physics III, 2005 − 2006

Problem Set 7.
Atoms with two and more electrons.

Problem 7.1*

(a) To the first order in the perturbation theory (treating the interaction between electrons as perturbation), compute the *ionization potentials* and compare them to the table values for the following atoms/ions: $I(\text{He}) = 24.6\text{eV}$, $I(\text{Li}^+) = 75.6\text{eV}$, $I(\text{Be}^{++}) = 154\text{eV}$, $I(\text{C}^{4+}) = 392\text{eV}$, $I(\text{O}^{6+}) = 739\text{eV}$.

(b) You may improve on the previous result by replacing the nucleus charge Z in the unperturbed Hamiltonian by an effective charge Z_{eff} and including the remaining charge $Z - Z_{\text{eff}}$ in the perturbation. Then you may variationally optimize Z_{eff} to lower the ground-state energy of the two-electron ion. Compare the results of this improved method to those obtained in part (a).

Problem 7.2

Using the quasiclassical approach, estimate the number of s-electrons in an atom with $Z \gg 1$ in the Thomas–Fermi model.