

Exam quantum mechanics

June 2016

You can use the book. Be clear, what is not clear cannot be corrected. You can answer in Dutch, French or English. If you want a Dutch translation of the exam questions, feel free to ask. Good luck!

Time-independent perturbation theory. [8pt]

- Discuss the coefficients a_{ii} in non-degenerate perturbation theory. Make sure you can back up your statements with explicit computations. [4pts]
- Discuss how one arrives at the secular equation of degenerate perturbation theory

Commutation relations and operator formalism [8pt]

- Consider the classical theorem $\frac{d}{dt}\vec{L} = \vec{r} \times \vec{F}$. How can it be obtained in quantum mechanics [3pts]?
- Consider the kinetic energy operator $-\frac{\hbar^2}{2m}\nabla^2$. Show that it commutes with L_z [3pts]
- Consider the 3D harmonic oscillator with potential $V = k_1x^2 + k_2(y^2 + z^2)$. We have that $k_1 \neq k_2$. Write down an explicit conserved observable by showing it commutes with the Hamiltonian. This observable has to be different from the Hamiltonian. [Hint: symmetries] [3pts]

Spin [4pt]

Consider two electrons for which all quantum numbers, but the spin, are equal. What is the resulting *total* spin of the two-electron system. Explain *and calculate* your answer. [Hint: fermion/boson statistics.]