Phys106, II-Semester 2018/19, Assignment 11

Instructor: Sebastian Wüster

1. Compare the Hydrogen energy states shown to you in the lecture, in terms of how likely it is for the electron to be very close to the nucleus. (Also rank them in terms of this). Explain your answer.

2. Verify separately for all the $n = 2$ Hydrogen states shown in the lecture hat: (i) The radial (r dependent) part of the wave function given to you fulfills Eq. (126), the azimuthal part (ϕ dependent part) fulfils Eq. (124) and the θ dependent part fulfils Eq. (125). *First identify which are those parts.*

3. In the lecture we will hint at the fact, that while it in some cases helps to imagine the spin of the electron as angular momentum due to it "spinning" around its own axis, this picture can not in fact be correct. To see this, assume the electron is a spinning uniform mass distribution in form of a sphere with radius $r_{el} = 5 \times 10^{-17}$ m (the present experimental upper limit on the electron size is even smaller than this). We can link the angular momentum of this sphere to its angular rotation frequency using

$$|\vec{L}| = I\omega, \tag{1}$$

   with moment of inertia $I = \frac{2}{5} m_e r_{el}^2$.

   Use these formula to find the equatorial velocity of the rotating electron (= how fast does its surface move at the fastest point)? Analyse your answer.

4. Imagine a classical model for the Hydrogen atom, where we ignore radiation emission. Consider also non-circular orbits. What is fixed by the requirement that the total energy be E_n (one of the quantum values)? How to we get motion that has zero angular momentum wrt. the nucleus? Some angular momentum? What would you imagine to be the "classical equivalent" of a Hydrogen ground state in this picture?

5. Solve the azimuthal differential equation for Hydrogen atom, Eq. 124, compare with the wave functions given to you.