LECTURE 4

Content

In this lecture we will discuss a simple model of the hydrogen atom - the **Bohr model**. We shall see how appplying quantisation rules leads to a discrete electronic energy spectrum for the hydrogen atom, and find an equation for the wavelength of light absorbed or emitted in an electronic transition. We shall compare the predictions of this simple model with the experimental values. Lastly we shall state the Correspondence Principle, and see how it applies to the energy spectrum of hydrogen.

Outcomes

At the end of this lecture you will:

- be able to describe the Bohr model of the atoms
- apply this description to hydrogen-like atoms to calculate the energy spectra
- be able to apply quantisation rules
- know the significance of the principal quantum number
- be able to use the Rydberg formula to calculate transition energies
- know the Correspondence Principle

LECTURE 4 SUMMARY

- The Bohr model is a simple model of hydrogen and hydrogen-like atoms.
- It assumes circular electron motion around a stationary nucleus
- Nevertheless, it produces surprisingly good agreement with experimental data
- Electrons are only allowed to occupy certain discrete states
- In hydrogen, the energies of these states scale as $E \propto n^{-2}$
- Transitions between these states involve the exchange of a photon, the energy of which is found from the Rydberg formula
- The Correspondence Principle: n the limit of large quantum numbers $n \to \infty$, QM results should tend to the classical results

LECTURE 5

Content

In this lecture we will analyse and criticise the Bohr model more closely - discussing the approximations made in the model, and highlighting its failings. We will introduce the convenient atomic units and spectroscopic units and review the quantum treatment of orbital angular momentum.

Outcomes

After this lecture you will

- know the definition of, and be able to use, the reduced mass of a system
- be able to criticise the simple Bohr model of the atom
- know and be able to use atomic and spectroscopic units
- recall the quantum treatment of angular momentum

LECTURE 5 SUMMARY

- finite nuclear mass effects are important
- the reduced mass is the effective mass of a system once the centre of mass motion is separated off
- Bohr model of the atom is OK… but not good enough
- atomic units, $\hbar = 4\pi\epsilon_0 = a_0 = e = m_e = 1$, and spectroscopic units (wavenumbers) are useful
- a quantum description of angular momentum is needed
- the operators $\underline{\hat{L}}^2$ and $\hat{L}_z$ have simultaneous eigenfunctions, which are the **spherical harmonics**

LECTURE 6

Content

In this lecture we will recap the form of the solution to the radial part of the Schrödinger equation for a hydrogen atom, and compare the solutions to the simple Bohr model. We will look at the degeneracy of the energy levels. Spectroscopic notation will be introduced. The spin part of the wavefunction will be introduced and the unavoidable conclusion that antiparticles are necessary to justify this will be discussed.

Outcomes

At the end of this lecture you will:

- recall the radial solutions to the Schrödinger equation for a hydrogen atom
- know that these represent a probability density
- be able to contrast these solutions with the simple Bohr model
- know spectroscopic notation
- know that the total wavefunction requires a spin component, and that this predicts the existence of antiparticles

LECTURE 6 SUMMARY

- The solutions to the radial part of the Schrödinger equation for the hydrogen atom, $R_{nl}(r)$, include and exponential decay and the associated Laguerre polynomials.
- unlike the Bohr model the electron does not have a fixed orbit, but there is a probability of finding the electron within a certain interval
- The quantity $r^2 R_{nl}^2$ is the radial probability density
- The energy eigenvalues, E_n, scale as n^{-2}
- In spectroscopic notation the angular momentum state is labelled with a letter, $s, p, d, f, g...$
- The total wavefunction for the hydrogen atom must include a spin component
- This arises from Dirac's relativistic theory of quantum mechanics, which also predicts the existence of antiparticles