UNIVERSITY OF HYDERABAD

School of Physics

Jan 2010 - Apr 2010 | Time : 1hr
M.Sc. II-Semester | Quantum Mechanics-I | MM : 20

WebQuest : Bohr Levels:Comparison with Expt

1 Introduction

The non-relativistic Schrodinger theory for the H atom predicts energy levels characterised by the principal quantum number n for which the energy levels are predicted to be at $-R/n^2$. There are in all $2n^2$ levels with $\ell = 0, 1, 2 \cdots, (n-1)$ for each ℓ m takes $2(\ell+1)$ values and spin can be up or down. All these level are predicted to be degenerate. Experimentally, all of these levels are not degenerate and there is further fine structure splitting, Lamb shift and hyperfine splitting. In this Web-Quest you will learn about the fine structure and Lamb shift.

2 Task

1. To figure out the relationship between different units of energy used in spectroscopy such Joules, eV, cm^{-1}, and Ry.
2. To understand the theoretical origin of fine structure of H atom energy levels
3. To compare theoretical predictions with experiments.
4. To know what are the remaining features of the H atom spectrum, Lamb Shift etc.

3 Process

1. Learn the derivation of the Spin Orbit Coupling
2. Compute the correction term in the Hamiltonian due to relativistic variation of mass
3. List all the l, m, m_s quantum numbers for $n = 1, 2, 3$ levels giving spectroscopic notation.
4. Explain why a change of basis to $nljm$ basis is more convenient for the fine structure calculations. Briefly explain, in your own words, how perturbation theory will be used to compute the fine structure splitting. Write all

expressions for corrections to energy levels as integrals but do not evaluate integrals.

5. Discuss the main features pf the perturbation theory result for the fine structure of H atom and compute the numerical values energy shifts of the levels with $n = 1, 2, 3$.

6. Present your results along with experimental numbers for the fine structure splitting of following levels

$$2s_{1/2}, 2p_{1/2}2p_{3/2}; 3s_{1/2}, 3p_{1/2}, 3p_{3/2}, 3d_{3/2}, 3d_{5/2}$$

7. Which fine structure for some energy levels are predicted to be zero. Identify the these levels, giving nlj quantum numbers for $n = 2, 3, 4$ only. Do the agree with this prediction? Present experimental numbers for these level differences in Mc and cm[1] in a tabular form.

4 Questions

What is the most important contribution to the differences in the enrgies of the following levels.

$$(a)2s_{1/2} - 3s_{1/2} \quad (b)2s_{1/2} - 2p_{3/2} \quad (c)3p_{1/2} - 3p_{3/2}(d)3p_{3/2} - 3d_{3/2}$$

5 Evaluation

1. Following the instructions [10]
2. Completion, discussion and presentation of results in different steps[25]
3. Free of Grammar and Spelling Errors [5]
4. Questions given above [10]