Further Quantum Physics H.T. 2009

John Wheater

Lecture Synopsis

This is a summary of what I intend to cover in the Hilary Term lectures. If we don't get through it all by the end of HT we'll finish off at the beginning of TT. The rest of TT will be taken up with time-dependent physics.

There is also a note of which sections of the Problem Set are relevant to each topic.

1. **Hydrogen gross spectrum** The spectrum, the wavefunctions and their characteristics in the Coulomb approximation. Section 1 of the Problem Set.

2. **The Hydrogen Hamiltonian** A discussion of the bits of physics we have omitted so far; relativistic correction to KE, the spin orbit interaction. Estimation of the size of these effects. Experimental discrepancies between real spectrum and the gross spectrum. Motivation to look for a calculational techniqe to take quantitative account of the perturbations.

3. **Perturbation theory** Time independent perturbation theory both degenerate and non-degenerate and simple one and two-dimensional examples. Section 2 of the Problem Set.

4. **Fine structure in Hydrogen** Perturbation theory calculation of the fine structure. The isotope shift and the discovery of Deuterium. Finite nuclear size effects. Section 3 of the Problem Set.

5. **External B field and the Zeeman effect** Estimation of size of B field required to produce detectable but small shift in spectrum. Discussion of conserved quantities in presence of B field and perturbative calculation of the Zeeman effect in Hydrogen. Section 4 of the Problem Set.

6. **Helium in the central potential approximation** Lack of agreement with experimental spectrum and estimation of the size of the electron-electron repulsion contribution to the Hamiltonian. Section 5 of the Problem Set.

7. **Variational principle** Derivation of the principle and its applicationto simple problems and to the Helium Hamiltonian including electron-electron repulsion. Section 5 of the Problem Set.

8. **Identical particles** Exchange symmetry and the Pauli exclusion principle. Wavefunctions for systems of two identical particles. Section 5 of the Problem Set.

9. **Singlet-triplet splitting in He** Conserved quantities and the labelling of energy eigenfunctions, including their exchange symmetry. Estimation of magnitude of singlet-triplet splitting. Section 5 of the Problem Set.

10. **Identical and Distinguishable** How to generate wavefunctions with the correct exchange symmetry for systems of more than two particles. A discussion of when identical particles can for practical purposes be regarded as distingushable. Section 6 of the Problem Set.

Books

As far as books go we are of course spoiled for choice in Quantum Mechanics but it is a little unfortunate that some of the best modern books are very expensive and therefore not really suitable as recommendations. All the books below should be in every college library.

- The basic recommendation is Gasiorowicz, *Quantum Physics*; this is now in its third edition (Wiley 2003) which is preferable but the second edition will do.
- The experimental detail we need is covered in Haken and Wolf *The Physics of Atoms and Quanta* (7th edition, Springer 2005).
- *Principles of Quantum Mechanics* by Shankar (2nd edition, Springer 1994) is an excellent more advanced book on quantum mechanics.
- *Elementary Atomic Structure* by Woodgate is a slightly more advanced book about atomic structure. It is mostly concerned with multi-electron atoms which you'll start to learn about next year.
- The *Feynman Lectures Vol III* are a invaluable source of insights from an extraordinary physicist and should be read by everyone intent on pursuing a career in physics.
- Dirac's classic *Principles of Quantum Mechanics* is compulsory reading for budding theorists; the summer vac would be a good time for that.