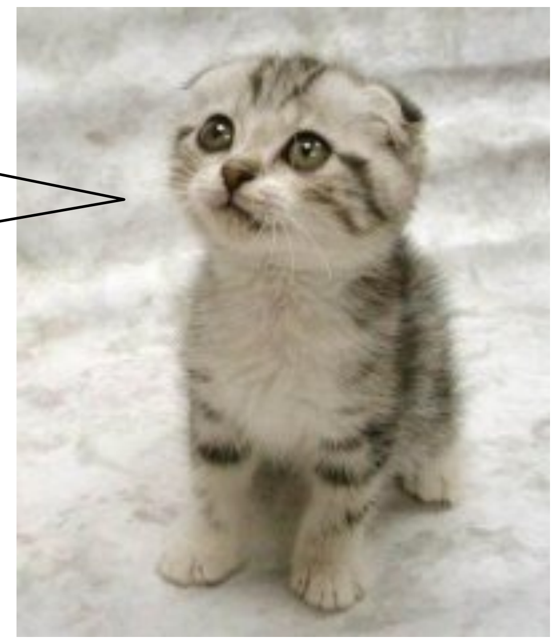
QM Revision Lecture

In this lecture we look back over the main themes and consider the key ideas you should be familiar with.

Are you sure it's just a thought experiment?



http://www.star.le.ac.uk/nrt3/QM/

Lecture 1

• Young's double slit experiment used to illustrate wave-particle duality. You should be able to determine angles of constructive and destructive interference.

• Energy (hf) and momentum of photons (h/λ). [more generally, $E^2 = p^2c^2 + m_0^2c^2$]

• Photoelectric effect to illustrate particle nature of light. Be able to do calculations involving work functions. $KE_{\mathrm{max}} = hf - \varphi$

• Compton scattering. Be able to derive and use the relation between wavelength change and scattering angle, starting from (special relativistic) energy and momentum conservation.

$$\Delta\lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

• Planck's constant and radiation law. h=6.63x10^{-34} J s $\hbar = h/2\pi$

• De Broglie matter waves. $\lambda = h/p$

• Heisenberg's uncertainty principle. $\Delta x \Delta p \geq \hbar/2$

Lecture 2

• The idea of wavefunctions to describe the state of particle properties in terms of probabilities. You should be able to normalise wavefunctions (so the total probability is unity) and calculate expectation values for the position of the particle.

$$\int_{-\infty}^{\infty} \psi^2(x)dx = 1 \qquad \int_{-\infty}^{\infty} x\psi^2(x)dx$$

• Understand the terms in the time-independent Schrodinger equation.

$$E\psi(x) = -\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + V(x)\psi(x)$$

• Standing wave wavefunctions as solutions for infinite potential well. Be able to normalise these and calculate energy levels using Schrodinger equation.

$$\psi_n(x) = \sqrt{\frac{2}{L}}\sin(n\pi x/L) \qquad E_n = \frac{h^2n^2}{8mL^2}$$

• Generalise the Schrodinger equation to simple problems in higher dimensions, such as particle in 3D box (and hence meet the concept of degeneracy).

Lecture 3

• For the "Harmonic oscillator" the potential is *parabolic*. We showed ground-state solution has form of a Gaussian function: $\psi(x) = Ce^{-ax^2/2}$, and found the ground state $E_0 = \frac{\hbar\omega}{2}$, while the separation between energy levels is a constant $\hbar\omega$.

• For the finite potential well the solutions within the well are again trig functions, but at the walls the wavefunctions become exponential decaying functions $\psi = Ae^{-x}$ etc. Be able to formulate complete solutions by solving the Schrodinger equation in the different regions and enforcing *continuity* and *differentiability* where the functions join at the walls.

Lecture 4

- Write plane wave wavefunction: $\psi(x,t) = Ae^{i(kx-\omega t)}$ and to use it in simple problems when a plane wave is incident at a potential step (reflection, transmission and tunneling). Recall, we still use the time-independent SE here.

- Explain quantum tunnelling and its importance in understanding radioactive alpha decay.

- Understand the terms of the time-dependent Schrodinger equation.

$$i\hbar\frac{\partial\psi}{\partial t} = -\frac{\hbar^2}{2m}.\frac{\partial^2\psi}{\partial x^2} + V(x,t)\psi(x,t)$$