QUANTUM MECHANICS

de Broglie

for ALL things, light & matter:

$\lambda = h/p$

$\nu = E/h$

Schrödinger Equation

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V\Psi$$

this is non-relativistic

Ψ can be complex-valued

boundary conditions lead to energy quantization

not derived (initially) but fit to reality

Time Independent Schrödinger Equation

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} + V\psi = E\psi$$

Quantum Things

- Mass, charge, etc.
- Energy (cf. blackbody radiation, photoelectric effect, photons & other fields)
- Interference – 2 slit experiment
- Tunneling (radioactive decay, electronic devices)
- Zero-point motion, i.e., electron never at 0 energy
- Diffraction in matter

Operators

position, $\langle x\rangle$: $\hat{x} = x$

a function of position, $\langle f(\boldsymbol{r})\rangle$: $\hat{f} = f(\boldsymbol{r})$

velocity, $\langle v\rangle = \frac{d\langle x\rangle}{dt}$: $\hat{\boldsymbol{v}} = \frac{\hbar}{im}\boldsymbol{\nabla}$

Note that this is velocity of expectation, but gives velocity in QM

momentum, $m\frac{d\langle x\rangle}{dt}$: $\hat{\boldsymbol{p}} = \frac{\hbar}{i}\boldsymbol{\nabla}$

energy: $\hat{H} = -\frac{\hbar^2}{2m}\boldsymbol{\nabla}^2 + V$

Hydrogen-like atoms

$H^0 = -\frac{\hbar^2}{2m_e}\nabla^2 - \frac{kZe^2}{r}$

$H^{rel} = -\frac{p^4}{8m_e^3c^2}$

$H^{s-o} = \frac{kZe^2}{2m_e^2c^2}\frac{1}{r^3}\vec{s}\cdot\vec{L}$

$H^{hf} = \frac{Ze^2}{4\pi\varepsilon_0}\frac{g_N}{4M_Nm_ec^2}\left(\frac{3\vec{r}(\vec{r}\cdot\vec{I})}{r^5} + \frac{8\pi}{3}\vec{I}\delta(\vec{r})\right)\cdot(\vec{L}+2\vec{s})$