# Modern

## Atomic physics and Quantum Effects

### Photo Electric Effect

- Description
  - Analysis of data <mod2.html> from the photoelectric experiment showed that the energy of the ejected electrons was proportional to the frequency of the illuminating light. This showed that whatever was knocking the electrons out had an energy proportional to light frequency. The remarkable fact that the ejection energy was independent of the total energy of illumination showed that the interaction must be like that of a particle which gave all of its energy to the electron! This fit in well with Planck's hypothesis <mod2.html> that light in the blackbody radiation <mod6.html> experiment could exist only in discrete bundles with energy
  - $E = h\nu$
- Energy Level Diagrams

### Photons

- E=hf Energy photon = Planks constant * Freq
- p=E/C Momentum is = Energy photon/speed of light
- Number of Photons Use the energy for one photon and then divide the total energy of the beam by this.

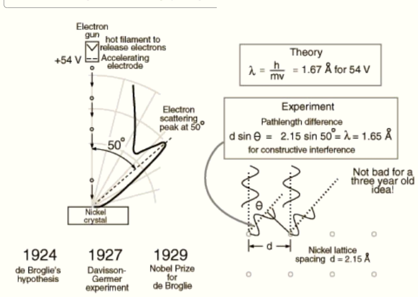
### Compton Scattering

- <compton.html> <compton.html> <compdat.html> <compdat.html>

  **Compton Scattering** Arthur H. Compton observed the scattering of x-rays <../ems3.html> from electrons in a carbon target and found scattered x-rays with a longer wavelength than those incident upon the target. The shift of the wavelength increased with scattering angle according to the Compton formula: Compton explained and modeled the data by assuming a particle (photon) nature for light and applying conservation of energy and conservation of momentum to the collision between the photon and the electron. The scattered photon has lower energy and therefore a longer wavelength according to the Planck relationship <../mod2.html> .
  - $\lambda_f - \lambda_i = \Delta\lambda = \frac{h}{m_e c}(1-\cos\theta)$
- Subtopic
  - At a time (early 1920's) when the particle (photon) nature of light suggested by the photoelectric effect <../mod1.html> was still being debated, the Compton experiment gave clear and independent evidence of particle-like behavior. Compton was awarded the Nobel Prize in 1927 for the "discovery of the effect named after him".

### Wave particle duality

- Suggested by De Broglie in about 1923, the path to the wavelength expression for a particle is by analogy to the momentum <mom.html> of a photon. Starting with the Einstein formula <relativ/releng.html> :
  - $E = mc^2 = KE + m_0c^2$
- Another way of expressing this is
  - $E = \sqrt{p^2c^2 + m_0^2c^4}$
- Therefore, for a particle of zero rest mass <relativ/tdil.html>
  - $p = \frac{E}{c}$
- For a photon <mod2.html> :
  - The momentum-wavelength relationship for a photon can then be derived and this DeBroglie wavelength relationship applies to other particles as well.
    - DeBroglie Wavelength $\lambda = \frac{h}{p}$
  - $E = h\upsilon = \frac{hc}{\lambda} \quad so \quad p = \frac{hc}{c\lambda} = \frac{h}{\lambda}$
- Davisson- Germer Experiment




  - This experiment demonstrated the wave nature of the electron, confirming the earlier hypothesis of deBroglie. Putting wave-particle duality on a firm experimental footing, it represented a major step forward in the development of quantum mechanics. The Bragg law <quantum/bragg.html> for diffraction had been applied to x-ray diffraction, but this was the first application to particle waves.

## Subatomic Particles

- Nuclear decay Mass Number and charge
  - Decay will cause a decrease in mass and charge.
- The Strong force
- Fission Neutron enters and 2 are produced
- Mesons
- Bosons
- Fermions
- Leptons

## Mass Energy

- $E := mc^2$