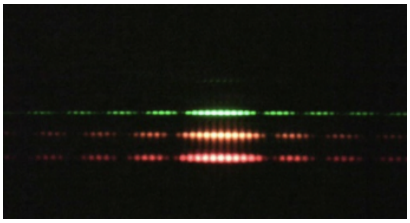
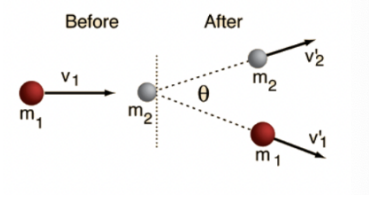
CAS PY 106

InClass Note 36

1. Light as a stream of particles (photons)
    a. Light consists of small packets of energy: photons
    b. Energy of one photon depends on frequency of light: E = hf
    c. Photon has no mass: m = 0. This kind of tells us we cannot use p = mv. Instead, we need special relatively, to tell us about the momentum of a photon: E = m^2 * c^4 = p^2 * c^2
    d. Photon has a momentum: p = E/c or p = hf/c
2. Light … wave or particle
    a. Properties of waves
        - have frequency and wavelength
        - can exhibit interference
        -



    b. Properties of particles
        - have momentum
        - can exhibit collisions
        -



c. Lights can be considered to be both
    - an electromagnetic wave, and/or stream of particles named photons

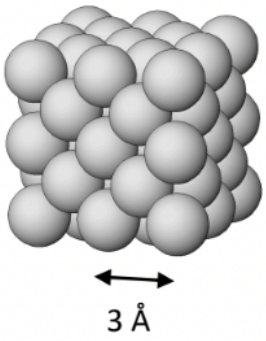
3. Wave-particle duality
    a. If waves (like light) can behave as particles (photons) then can particles (like electrons) behave like waves?
        - Yes! All particles also behave like waves
    b. Photons have no mass. Therefore, their energy and momentum is E = hf and p = E/c
    c. A particle with mass m has a “de Broglie Wavelength” of
        - lambda = h/p = h/mv
4. de Broglie wavelength of a walking person…
    a. Typical walking speed is 2m/s (about 4.5miles/hour)
    b. average mass of a person: 80kg
    c. Planck’s constant: h = 6.626 * 10^-34 J * s
    d. wavelength = 4.12 * 10^-36m
5. de Broglie wavelength of a 10eV electron…
    a. Remember 1eV = 1.6*10^-19 J
    b. Mass is m = 9.11 * 10^-31 kg
    c. 10eV refers to its kinetic energy: K = ½ * mv^2 = 10 * (1.6 * 10^-19) J
    d. Solving for speed: v = 1.87 * 10^6 m/s
    e. Planck’s constant: h = 6.626 * 10^-34 J * s
6. Can you produce a diffraction pattern using electrons?
    a. double slit diffraction: d*sin(theta) = m * lambda

b. lambda = 3.88 * 10^-10 m

c. Yes, totally, you would need slits that are 10^-10 meters apart

d. Typical spacing between atoms is 1 Angstrom (10^-10 meter)

e.

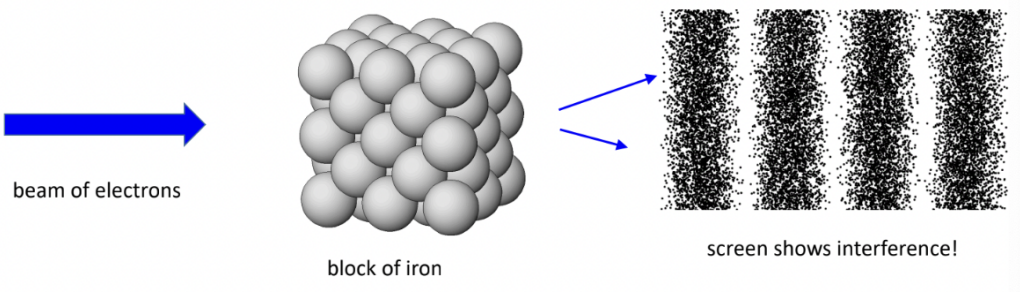


7. Electron diffraction

a. using the crystal structure of a material, you can produce diffraction patterns with electrons

b. Wave-particle duality: particles such as electrons can exhibit wave phenomena such as interference, with their wavelength given by lambda = h/p

c.



8. Electron microscope

a.