University of Virginia

Department of Physics

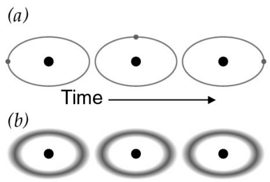
Physics 606: How Things Work II

Lecture #30 Slides:

Fluorescent Lights II

Atomic Structure

- Electrons travel as waves
- Electron in an orbital doesn't emit light
- Electron emits light when changing orbitals



Light from Atoms

- Light
  - travels as a wave (a diffuse structure)
  - is emitted or absorbed as a particle (a photon)
- Photon energy = Planck constant · frequency
- An atom's orbitals have specific energy differences
- Energy differences establish photon energies
- An atom emits a specific spectrum of photons

Electron/Atom Collisions

- An electron bounces off an atom
  - Electron loses no energy → atom is unaffected
  - Electron loses some energy → atom becomes excited
  - Electron loses lots of energy → atom is ionized

Atomic Fluorescence

- Excited atoms lose energy via radiative transitions
- During transition, electrons shift to lower orbitals
- Photon energy is difference in orbital energies
  - Small energy differences → infrared photons
  - Moderate energy differences → red photons
  - Big energy differences → blue photons
  - Very Big differences → ultraviolet photons
- Atoms typically have bright "resonance lines"
- Mercury's resonance line is at 254 nm, in the UV

Phosphors

- A mercury lamp emits mostly invisible UV light
- To convert its UV light to visible, use a phosphor
- Phosphors absorb photons and reemit new photons
- New photon energy is less than old photon energy
- Fluorescent lamps → phosphors emit white light
  - (Deluxe) warm white, (deluxe) cool white phosphors
- Specialty lamps → phosphors emit colored light
  - Blue, green, yellow, orange, red, violet, etc.

Question:

A fluorescent lamp tube is coated with a white powder on its inside surface. If that powder were not there, would the lamp appear brighter, dimmer, or about the same overall brightness, but with an unpleasantly bright white line near its center?

Fluorescent Lamps 2

- Starting discharge requires electrons
- Heated filaments can provide electrons
  - Manual preheat lamps (initial filament heating)
  - Automatic preheat lamps (initial filament heating)
  - Rapid start lamps (constant filament heating)
  - Only rapid start lamps can be dimmed
- High voltages can provide electrons
  - Instant start lamps (high voltage pulse start)

Fluorescent Lamps 3

- Gas discharges are unstable
  - Gas is initially insulating
  - Once discharge is started, gas become a conductor
  - The more current it carries, the better it conducts
  - Current tends to skyrocket uncontrollably
- Stabilizing discharge requires ballast
  - Inductor ballast (old, 60 Hz)
  - Electronic ballast (new, high frequency)

Low-Pressure Discharge Lamps

- Mercury gas emits ultraviolet resonance light
  - Low pressure mercury lamps emit ultraviolet light
- Some gases emit visible resonance light
- Low pressure sodium emits yellow-orange light
  - Very energy efficient
  - Extremely monochromatic and unpleasant

Pressure Broadening

- High pressures broaden each spectral line
  - Collisions occur during photon emissions
  - Frequency and wavelength become less sharply defined
  - Collision energy compensates for photon energy

Radiation Trapping

- Radiation trapping occurs at high densities
  - Atoms emit resonance radiation very efficiently
  - Atoms also absorb resonance radiation very efficiently
  - Resonance radiation photons are trapped in the gas
  - Energy can only escape discharge via other transitions