Chapter 3

Radiation

Units

Waves – Information from the skies

Waves in What?

- The Wave Nature of Radiation

The Electromagnetic Spectrum

Thermal Radiation

- The Kelvin Temperature Scale
- More about the Radiation Laws

The Doppler Effect

3.1 Waves

Electromagnetic Radiation: energy transmitted through space as varying electric and magnetic fields

Examples: Light,

radio waves,

X-rays, IR

***Not* beta rays (e-)**

or alpha rays

3.1 Waves

Wave motion: **transmits energy without the physical transport of material**

3.1 Waves

Example: water wave

Water just moves up and down

Wave travels and can transmit energy

3.1 Waves - terminology

Frequency: number of wave crests that pass a given point per second

Period: time between passage of successive crests

Relationship: **Frequency = 1 / Period**

3.1 Wave terminology

Wavelength: distance between successive crests

Velocity: speed at which crests move

Relationship:

Velocity = Wavelength / Period

3.1 Wave terminology

Visible spectrum:

ROYGBIV

3.2 Waves in What?

Water waves, sound waves, and so on, travel in a medium (water, air, …)

Electromagnetic waves need no medium

Created by accelerating charged particles:

3.2 Waves in What?

Electromagnetic waves: Oscillating electric and magnetic fields. Changing electric field creates magnetic field, and vice versa

3.2 Waves in What?

What is the wave speed of electromagnetic waves?

$$c = 3.0 \times 10^8 \text{ m/s}$$

This speed is very large, but still finite; it can take light millions or even billions of years to traverse astronomical distances

3.2 Waves in What?

The wave nature of radiation: radiation diffracts, which is purely a wave phenomenon

3.3 The Electromagnetic Spectrum

No upper limit on wavelength

Different ranges have different names

3.4 Thermal Radiation

Blackbody Spectrum: the electromagnetic spectrum produced by a hypothetical object which can absorb 100% of incident light. The spectrum obeys a particular equation which depends only on the temperature.

3.4 Thermal Radiation

Radiation Laws

1. Peak wavelength is inversely proportional to temperature

3.4 Thermal Radiation

Kelvin Temperature scale:

- **All thermal motion ceases at 0 K**
- **Water freezes at 273 K and boils at 373 K**

3.4 Thermal Radiation

Radiation Laws

2. Total energy emitted is proportional to fourth power of temperature (note intensity of curves)

3.5 The Doppler Effect

If one is moving toward a source of radiation, the wavelengths seem shorter; if moving away, they seem longer

3.5 The Doppler Effect

Relationship between frequency and speed:

$$\frac{\text{apparent wavelength}}{\text{true wavelength}} = \frac{\text{true frequency}}{\text{apparent frequency}}$$

$$= 1 + \frac{\text{recession velocity}}{\text{wave speed}}$$

3.5 The Doppler Effect

Depends only on the relative motion of source and observer: