Light and Matter (part of Chapter 5): Light (Matter was discussed earlier)

Light and matter interact in the following processes: emission, absorption, transmission, and reflection/scattering. Reflected light goes in a certain direction. Scattered light goes in all directions.

White light can be separated into a rainbow of colours by a prism. A red piece of glass transmits only red light, absorbing the rest. A red piece of paper scatters only red light, absorbing the rest.

Light has some of the properties of particles and some of the properties of waves. Light comes in isolated packages, called photons, that have a specific frequency and wavelength. All frequencies of light travel at the same speed, c. The speed of light equals the product of its frequency and wavelength. The energy of a photon is the product of its frequency and Planck's constant. One photon with a high frequency and high energy interacts with matter very differently from one hundred photons with lower frequencies and lower individual energies, but the same total energy.

Atoms can store energy in the electrical potential energy of their electrons. Electrons are only allowed to have certain amounts of energy and their energy levels are quantized. When an atom absorbs a photon, the energy of the photon is used to change an electron's energy level. So atoms can only absorb photons whose energy equals the difference between two energy levels. Atoms can only emit photons whose energy equals the difference between two energy levels. This causes gases to have characteristic emission and absorption spectra. Unlike atoms, molecules can also store smaller amounts of energy in motion associated with molecular rotation or vibration. This gives molecules more complicated spectra than atoms.

The motion of molecules within an object or cloud of gas leads to emission over a broad range of wavelengths. This emission depends only on the object's temperature and is called thermal emission. For planets, thermally-emitted photons have much lower energies than those associated with differences between electron energy levels.

Light is affected by motion of the object emitting the light. Its wavelength (and frequency) change, but not its speed. $v / c = (\lambda_{shifted} - \lambda_{rest}) / \lambda_{rest}$. This Doppler shift can be used to study how stars and planets are moving and rotating.