ASTR 1120 Section 1 (3 credit hours): Spring 2006

SUMMARY OF KEY CONCEPTS: WEEK #3

Lecture #5 – textbook Chapter 14 (4th edition) or 15 (3rd edition): `Our star'

Concept of **gravitational equilibrium** – how does the Sun and other stars support itself stably against the force of gravity which otherwise would cause a rapid collapse? We noted two things: first that at each radius in the Sun there is a balance between the inward force of gravity and an outward *pressure gradient* (high pressure in the center, low pressure at the surface). The high pressure comes about because an ordinary gas' pressure increases with temperature and density, and the center of the Sun is very hot! Second, the core of a star acts as a kind of thermostat to prevent a runaway nuclear reaction – if the rate of nuclear reactions increases the core expands and (counter-intuitively) cools off, restoring the balance.

Photons produced in the Solar core leak out of the Sun very slowly – over thousands of years or longer – because of multiple collisions along the way.

Nuclear reactions in the core also produce subatomic particles called neutrinos, which have the property of interacting extremely weakly with ordinary matter. They can easily escape the Sun without being scattered or absorbed. This allows us a window into the Solar core – flip side is that it's very hard to capture the neutrinos in experiments on Earth and detect them.

The Solar neutrino problem was an apparently large discrepancy between the predicted number of Solar neutrinos (from models of the Sun) and the number actually measured in experiments mostly situated deep underground. The eventual resolution of the problem was that electron neutrinos, the type produced in the core, can change into other flavors (muon and tau neutrinos) on their way to Earth. Early experiments could only detect the electron neutrino, leading to the apparent shortfall.

Lecture #6 – textbook Chapter 5 (4th edition) or Chapter 6 (3rd edition) on `Light'

We summarized the different sources of information we can glean about the Universe – light (images and spectra, a spectrum divides light into its constituent colors), neutrinos, dust and rocks from the Solar System, and in the future gravitational waves. Light is much the most important.

Gamma-rays, X-rays, ultraviolet, visible light, infrared and radio waves are all the same basic phenomenon, called *electromagnetic radiation*. Electromagnetic radiation has (simultaneously and weirdly, this is quantum mechanics) both particle and wave properties. Viewed as a particle, the basic unit is the photon – a single particle of light. Photons have specific energies, and in a vacuum all travel at the same speed – the speed of light c = 300,000 km/s. A bright source just emits more photons than a dim source of the same color.

Viewed as a wave, electromagnetic radiation has 4 properties – the speed (c, the same as for photons), the *wavelength* (denoted by the greek letter λ - lambda – this is the distance between successive peaks in the wave), the *frequency* f (how many peaks pass by each second, measured in units of cycles per second or Hertz), and the *amplitude* which is a measure of the brightness of the wave.

An important relation exists between the wavelength, frequency and speed of a wave:

WAVELENGTH x FREQUENCY = SPEED

…or $\lambda f = c$. You need to understand how this works – short wavelength electromagnetic radiation has a high frequency whereas long wavelengths mean low frequency (this is simple because all electromagnetic radiation has the same speed).