ASTR 1020

Look over Chapter 15

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Triangulation

Astronomers have several methods for measuring a star's distance, but for nearby stars the technique used is **Triangulation**.

In triangulation, we construct a triangle in which one side is the distance we want to know but can not measure and one side is a distance we can measure.

Parallax and Distance

Astronomers use a method of triangulation called **Parallax** to measure the distance to stars.

Nearby objects exhibit more parallax then more remote ones.

Measuring Parallax

Astronomers define a star's parallax, ***p***, not by the angle its position appears to shift, but by half that angle.

Parsac

With that definition of parallax a stars distance is simply:

$$d = \frac{1}{p}$$

Where *d* is measured in **Parsecs**.

Parsec is ***par***allax per ***sec***ond of arc.

$$1\ parsec = 3.26\ lightyears$$

Measuring the Properties of Stars From Light

Astronomers want to know the size, colors, and structure of stars.

By analyzing a star's light, astronomers can deduce many of the properties of the stars.

Intrinsic Brightness

We can judge apparent brightness easily, but unless we know the distance to individual points of light, we cannot determine their intrinsic brightness.

Once an astronomer determines the distance to a star, however, it is simple to calculate its intrinsic brightness from its apparent brightness and its distance.

Absolute Visual Magnitude

Intrinsic brightness of a star is measured using **Absolute Visual Magnitude**.

This is the apparent visual magnitude the star would have if it where 10 parsec away.

The intrinsically brightest stars known have absolute magnitude of about –8, and the faintest about +19.

The Magnitude-Distance Formula

The Magnitude-Distance Formula relates the apparent magnitude m_v, the absolute magnitude M_v, and the distance d in parsecs:

$$m_v - M_v = -5 + 5\log_{10}(d)$$

If we know any two of the parameters in this formula we can easily calculate the third.

The Distance Modulus

If you know the apparent and absolute magnitude then you can find the distance using:

$$d = 10^{\frac{m_v - M_v + 5}{5}}$$

The magnitude difference m_v-M_v is known as the **Distance Modulus**, a measure of how far away the star is.

Luminosity **(L)**

The **Luminosity** of a star is the total amount of energy the star radiates in one second—not just visible light, but all wavelengths.

Adding the proper correction to the visual magnitude changes it into the Absolute Bolometric Magnitude —the absolute magnitude the star would have if we could see all wavelengths.

Luminosity, Radius and Temperature

The luminosity and temperature of a star can tell us its diameter if we understand the two factors that affect a star's luminosity:

Surface Area and **Temperature**.

$$L = 4\pi R^2 \sigma T^4$$

Comparing Luminosity

If we know the luminosity and size of a star (like the Sun) we can use that information to find the size of another star as:

$$\frac{L_1}{L_2} = \left(\frac{R_1}{R_2}\right)\left(\frac{T_1}{T_2}\right)^2$$

So if we know the luminosity and the temperature of a star we can calculate how much bigger or smaller then the Sun a star is.

The Balmer Lines

To measure the temperature of a star we can look at the **Balmer Lines** of the Hydrogen spectra.

Balmer lines are labeled by Greek letters.

The Balmer Thermometer

We can use the Balmer absorption lines as a thermometer to find the temperature of stars.

The Balmer lines are useful since they are produced by electrons when they jump from the 2^{nd} energy level up to a higher one.

Other Elements

Temperature has a similar effect on the spectral lines of other elements, but the temperature at which they reach maximum strength differs for each element.

Spectral Classification

The classification includes the seven **Spectral Classes**, or **Types** still used today.

$$O, B, A, F, G, K, M$$

O, B, A, F, G, K, M

This sequence of spectral types called Spectral Sequence, is important because it is a temperature sequence.

The O stars are the hottest, and the temperature continues to decrease sown to the M stars, the coolest.

Graphs

With the rise of computers astronomers display spectra as graphs of intensity versus wavelength.

The H–R Diagram

The **Hertzsprung-Russell (HR) diagram**, named after its originators, Ejar Hertzsprung and Henry Narris Russell, is a graph with luminosity on the vertical axis and temperature on the horizontal axis.

A star is represented by a point on the graph that tells us the luminosity of the star and its temperature.

Patterns in the H-R Diagram

Most stars fall somewhere along the **Main Sequence**, the prominent streak running from the upper left to the lower right on the H-R diagram.

The stars along the top are called **Supergiants** because they are very large addition to being very bright.

Just below the supergiants are the **Giants**, which are somewhat smaller in radius and lower in luminosity (but still much larger and brighter then main-sequence stars of the same spectral type).

The stars near the lower left are small in radius and appear white in color because of their high temperature; we call these stars the **White Dwarfs**.

The Main Sequence

The **Main Sequence** is the region of the H-R diagram running from upper left to lower right. It includes roughly 90% of all stars.

At the lower right lie the coolest main sequence stars, the **Red Dwarfs**, Stars that are both small and cool

Stars spend most of their life-times on the main sequence burning fusing hydrogen. This is called the Main-Sequence Lifetime.

They Might Be Giants

The **Giant Stars** lie at the right above the main sequence.

The **Supergiants** lie near the top of the H-R diagram and are 10 to 1000 times the size of the Sun.

Giants and supergiants are stars near the end of their lifetimes. Strangely stars burn more energy as the get older so they become larger.

White Dwarfs

The stars at the lower left are hot stars, but they are very faint because they are very small, so they are called **White Dwarfs** because the brightest shine with a blue-white color

White dwarfs are the leftover cores of giants and supergiants.

Luminosity Classification

Main-Sequence stars are relatively small and have dense atmospheres in which the gas atoms collide often and distort their electron energy levels. Thus lines in the spectra of main-sequence stars are broad.

On the other hand, giant stars are larger, their atmosphere are less dense, and the atoms disturb one another relatively little. So their spectra are more narrow.

Luminosity Classes

So we can look at a star's spectrum and tell roughly how big it is. These are called **Luminosity Classes**, because the size of the star is the dominating factor in determining luminosity.

The luminosity classes are represented by the Roman numerals I through V, with supergiants further subdivided into types Ia and Ia.

Classes of Stars

Luminosity Classes	
Ia	Supergiants
Ib	Dimmer Supergiant
II	Bright giant
III	Giant
IV	Subgiant
V	Main-sequence

Binary Star Systems

The most important property of a star is its mass, but stellar masses are hard to measure.

We can measure stellar masses only in binary star system in which we can determine the orbital properties of the two stars.

Visual Binary Stars

A **Visual Binary** is a pair of stars that we can see orbiting each other.

Eclipsing Binary Stars

An **Eclipsing Binary** is a pair of stars that orbit in the plane of our line of sight

Spectroscopic Binary Stars

If a binary system is neither visual nor eclipsing we may be able to detect its binary nature by observing Doppler shifts in its spectral lines.

Because we detect the binary nature of such star systems by studying their spectra, they are called **Spectroscopic Binary Stars**.

Variable Stars

Not all stars shine steadily like our Sun. Any star that significantly varies in brightness with time is called a **Variable Star**.

The Rise and Fall of Luminosity

In a futile quest for a steady equilibrium, the atmosphere of these Pulsating Variable Stars alternately expand and contract, causing the star to rise and fall in luminosity.

Cepheid and R R Lyrae Stars

Most variable stars inhabit a strip called the Instability strip on the H-R diagram.

There are two special types of stars the **Cepheid Variables** that have a period of days and the smaller **RR Lyrae** stars that have periods of hours.

Period-Luminosity Relation

Since the longer the period for a pulsating star the bigger the size of the star, there is a relation between the period and luminosity.

This **Period –Luminosity** relation states:
The longer the period, the more luminous the star.

Clusters Formation

Stars can form in groups or clusters out of interstellar gas clouds.

Every star in a given cluster formed at the same time, from the same interstellar cloud, with virtually the same composition. Only the mass varies from one star to another.

Stellar Cluster Types

Open Cluster are Thousands of bright hot, young stars that are loosely associated.

Globular Cluster are fainter cooler, older star collections containing hundreds of thousands of stars tightly bound stars.

Cluster Evolution —The Beginning

O B A F G K M

Shortly after the cluster's formation the upper part of the main sequence is already fully formed and lower mass stars are just beginning to arrive.

10 Million Years

O B A F G K M

The most massive O-type stars have evolved off the main sequence. Most have already exploded and vanished, but one or two may still be visible as red supergiants.

100 Million Years

O B A F G K M

After 100 million years stars brighter then B5 or so have left the main sequence, and a few more red supergiants are visible.

1 Billion Years

The main-sequence turnoff mass is now around 2 solar mass or spectral type A2. The subgiant and giant branches associated with the evolution of low mass stars are just becoming visible.

10 Billion Years

The turnoff point has now reached solar mass stars of spectral type G2. The subgaint and giant branches are now clearly seen.

Main Sequence Turnoff

Astronomers refer to the high-luminosity end of the observed main sequence as the **Main-Sequence Turnoff**. The mass of the stars that is just turning off the main sequence at any moment is known as the **Turnoff Mass**.

Age of The Cluster=Lifetime of Stars at Main Sequence Turnoff Point