

## UNIT 11 - RADIAL MOTION OF STARS

### Introduction

Although we perceive the stars to be stationary (except for their apparent motion across the sky due to the Earth's rotation), the fact is, they are all moving relative to us with large speeds. We do not normally notice this motion due to the fact that the stars are so far away from us that the change in their angular position (given by right ascension and declination) is very small.

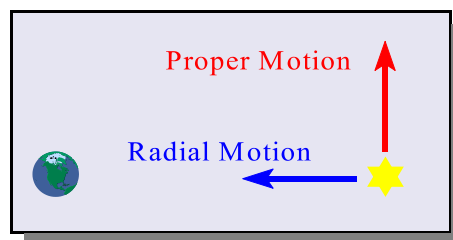


Figure-1

The motion of the star can be divided into two parts, *proper motion* (tangential motion) across the sky, and *radial motion* which is directed along our line of sight towards or away from us. Proper motion becomes apparent if the position of a star is measured and recorded for many years, in which case its position is observed to change slowly over time. Radial motion is not so obvious, and has to be measured indirectly by use of the phenomenon known as the Doppler Effect.

### Doppler Effect

When viewed through the proper instrument, the light from the stars contains line spectra which are characteristic of the elements existing in the star. The wavelengths of these spectral lines can be measured in the laboratory, and are well known. However, when a star moves along the line of sight between the Earth and the star, then the light it emits is detected with a slightly shifted wavelength. This shifting of wavelength due to an object's motion is known as the Doppler Effect.

By measuring the Doppler shift (change in wavelength) we can obtain a measurement of the radial velocity of a star. If the light is Doppler shifted to longer wavelength, this is known as a red shift, and indicates that the star is moving away from us. If the light is Doppler shifted to shorter wavelength, this is known as a blue shift, and indicates that the star is moving towards us. The relative change in wavelength tells us the radial speed of the star according to the formula:

$$\frac{\text{Change in wavelength}}{\text{True wavelength}} = \frac{\text{Speed of star}}{\text{Speed of light}}$$

where the speed of light is  $3.00 \times 10^8$  meters/sec.

### Instructions

1. Select *Radial Motion of the Stars* from the *Start Lab* menu.
2. The window contains a view of the sky containing 20 stars by default. You may change this number using *Number of Stars* from the overhead menu.
3. If you click on any star, the spectrum of hydrogen will be displayed. The hydrogen spectrum displayed above the horizontal axis is that measured in a lab; the hydrogen spectrum displayed below the horizontal axis is that of the star. Since the speed of light is so large, the

change in wavelength is too small to be seen on this scale. However, if you click on any one of the four spectral lines you will see a greatly expanded view of that portion of the spectrum, in which the wavelength change is easily noticeable.

4. Measure the change in wavelength using the grid which appears along with the spectrum. Each square on the grid corresponds to a wavelength change of 0.015 nanometers (nm). Note also the identification number for the star.
5. Repeat the measurement for each of the four lines in the spectrum, and for each of the stars. Create a data table to record your results.
6. Select *Check Your Results* from the overhead menu to complete the data analysis:
  - a. Enter the identification number of the star.
  - b. Enter the Doppler shift of the wavelength for each one of the spectral lines.
  - c. Enter the fractional Doppler shift for each one of the spectral lines - defined as the change in wavelength divided by the true wavelength. The true wavelengths are given as headers to the columns.
  - d. Enter the average fractional Doppler shift of all four lines.
  - e. From the average fractional Doppler shift, calculate the radial speed of the star using equation (1) and enter the result in the last entry field.
  - f. Click on the button labeled *Check your results* at the bottom of the window. Correct results will be indicated with a check mark.