

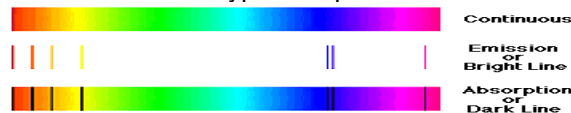
### Topic 3 - The Spectroscope: New Meanings In Light

#### Spectral Lines

Isaac Newton passed a beam of light through a prism to produce a *spectrum* of colors. If you pass the light through a narrow slit before sending it through a prism (a *spectroscope* is a device that does this) the spectrum will be in more detail. Joseph von Fraunhofer used a spectroscope to observe the spectrum produced by the Sun. He noticed dark lines, called *spectral lines*, but didn't know what they meant. He found these spectral lines throughout the solar system.

#### Spectroscopy: The Science of Colour

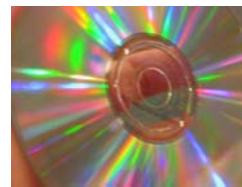
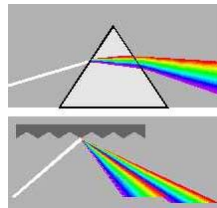
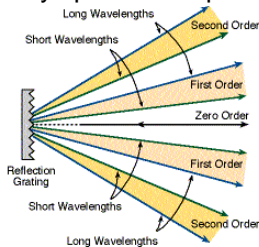
The significance of the spectral lines was discovered about 50 years later when Kirschhoff and Bunsen, two chemists used a spectroscope to observe various chemicals when they were heated. They found some of the lines missing in some of the chemicals. Each particular element had its own unique spectral lines. This led to the science of *spectroscopy – the study of spectra*, as a part of chemistry. They found that there were three types of spectra.



#### Diffraction Gratings

<http://www.thespectroscopynet.com/Educational/diffraction.htm>

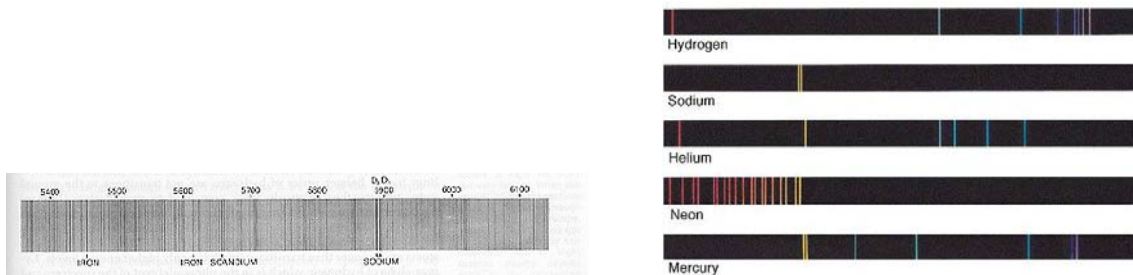
Besides splitting light using spectroscopes or prisms, a *diffraction grating* can, by using thousands of closely spaced slits produce much better detail in the spectrum it produces.



The rainbow spectra that can be observed on a CD are produced because the grooves on a CD act as a diffraction grating.

#### Spectroscopy for Astronomers

Astronomers refract the light from distant stars to determine what the star is made of. Stars have dark bands in distinct sequences and thicknesses on their spectra. Each element that is present in the star creates its own black-line 'fingerprint'.

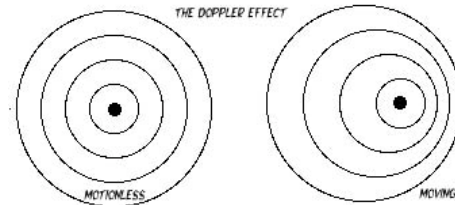
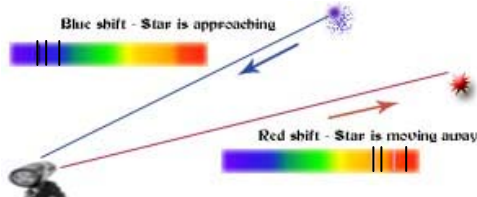


The spectra of the star are then compared to known spectra of elements to determine the star's composition. This is called *spectral analysis*. A **spectrometer** is used to do this.

By attaching spectroscopes to their telescopes, astronomers are able to observe a star's spectra, but because the distant stars are much dimmer than our Sun, only some of the elements in the spectra can be identified. Those that cannot be identified remain as inferences, based on what astronomers know about certain types of stars.

## The Doppler Effect

A change in the pitch (frequency) of sound waves because they are stretched or squeezed is known as the **Doppler effect**. Changes in the sound waves can be measured to determine how fast and in what direction a light-emitting object is moving.



The position of the dark bands is what shifts in the light waves of a moving star.

The spectrum of an **approaching star** shows the dark bands **shifting to the blue end of the spectrum**, whereas, the **shift is to the red part of the spectrum** if a **star is moving away from the Earth**.

The amount of shift indicates the speed at which the star is approaching or moving away.

There are also practical applications that use the Doppler effect.

Law enforcement officers detect the speed of an approaching vehicle by using a **radar gun**, which sends out a radio signal and receives one back from the vehicle. To determine the speed of the vehicle, the hand-held device records the difference in the outgoing wavelength and incoming wavelength.



## An Amazing Tool

The spectroscope is an amazing tool. It's application to astronomy has helped astronomers determine the composition of distant stars