Astronomical Spectroscopy

1. Introduction

We all know the stars in the constellation of Orion. Looking at them carefully we notice they are not all the same colour. Betelgeuse in the upper left corner is quite red and Rigel in the lower right corner is blue. Why do they have different colours? To understand this we must understand how a star produces light. This is the first important clue to the temperature of stars.

2. Temperature and heat.

The temperature of a star is a clue to properties such as the size of the star. If we do not know the temperature of a star we know almost nothing of the star. A distinction must, however, be made between 'heat' and 'thermal energy'. The two are not the same. Gas is made up of particles; atoms and molecules, in constant motion. It is not only the particles in a gas that are moving but particles in a fluid or a solid are also moving. The temperature of gas is the average velocity of the particles. If the particles in a fluid or a solid are agitated we say it is hot. What is the difference between thermal energy and heat? A glass of water and a large vat of water may have the same temperature, but the vat contains more thermal energy. Thermal energy is the total amount of energy stored in a body as motion among its particles.

3. Astronomical spectroscopy

Astronomical spectroscopy is the technique used by astronomers to analyse the light emitted by stars to measure the spectrum of electromagnetic radiation including visible light radiated by stars and other celestial objects. (Michael A. Seeds. 2001. Foundations of Astronomy. Brooks/Cole) Spectroscopy can be used to measure

various properties of stars and galaxies such as chemical composition, temperature, density, mass, luminosity and, using the Doppler Shift technique, the relative motion of the star or galaxy.

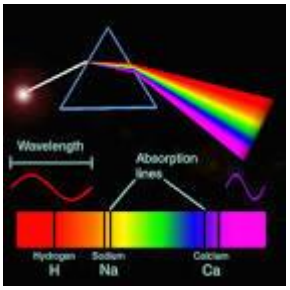
4. Spectroscopy as a tool

Spectroscopy can be used to determine various properties of a star. See below. The light, or photons emitted by the star reach us from the photosphere of the star that is the upper atmosphere. Photons are also emitted deep inside a star, but they are being bounced back and forth and can take ages before it reaches the photosphere of a star. Various elements have all various levels (called energy levels) where a photon (or photons) with the required energy can be absorbed at the energy level surrounding the atom. If a photon enters an energy level but does not have the required amount of energy, it will not be absorbed by the atom. On the other hand a photon with the exact amount of energy can be absorbed by the atom. Absorption lines in the spectra will show a black line in the spectrum. A photon can leave the level of energy required by the atom but it will have to absorb energy and will show a bright line. A level of energy (or energies) can only absorb a certain number of electrons per level as required by the Pauli Exclusion Principle. The line of absorption (or emission) of an element is unique. Each element has its own unique spectra. No other element has the same.

Chemical properties

Continuous spectrum

Emission lines



The flux units per wavelength is important in the measuring of the wavelength of the emission or absorption are important to determine the results.Main absorption lines in sun-like star spectra show the following:

At 0.2 flux and wavelength of 400 nm is Ca 393.3 nm and Calcium 396.8 nm. Natrium can for instance be found at about 0.8 flux per wavelength of 517.5nm. (edX ANU –ASTRO 1xGreatest unsolved Mysteries of the Universe. A series of lectures presented by Australian acedemics.)

The light emitted by Calcium has the wavelength of 517.5 nm and no other element has the same wavelength. Spectroscopy is therefore an invaluable tool to determine various properties of stars.

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