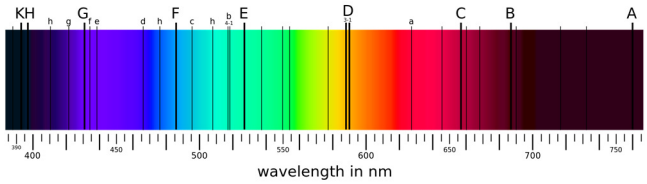
Sun – Part 7 - Spectroscopy 1

Isaac Newton

Joseph von Fraunhofer



Fraunhofer lines

Spectroscopy studies the interaction between matter and electromagnetic radiation. It is central to the study of astronomical objects, as information about them can only be obtained indirectly. The ability to determine the characteristics and composition of different types of celestial objects eg stars, nebulae, galaxies etc as well as details like their temperature, pressure, density, and mass is possible only because of the nature of electromagnetic radiation and light.

The achievements of astronomical spectroscopy were made possible because of the work and insight of a relatively small number of pioneering scientists.

Although he was not the first to study and report on light emitted by the Sun, Isaac Newton is often regarded as the father of spectroscopy. In 1666, during his optic experiments, he discovered that a prism breaks white light up into different colours and that different colours were refracted at different angles. He concluded that colour is a property intrinsic to visible light and applied the term 'spectrum' to describe the rainbow of colours that combine to form white light.

The discipline of spectroscopy, thus, originated in study of light dispersed, according to wavelength, by a prism. Later, the concept expanded to comprise any interaction with radiative energy as a function of wavelength or frequency. A number of devices have been developed to produce and study spectra. These include, spectrometers, spectrophotometers, spectrographs, and spectral analysers.

The development of astronomical spectroscopy was inextricably linked with advances in chemistry. Once it was realised that atoms and molecules have unique spectra, spectroscopy became central to the advancement of chemistry, particularly in the race to identify chemical elements. It was a chemist, the British scientist William Wollaston who, in 1802, was the first to note the appearance of several dark features in the Sun's spectrum.

However, the father of spectroscopy as an astronomical tool is widely accepted to be Joseph von Fraunhofer. In 1814, the highly skilled German optician and scientist built the first spectrometer in order to measure the dispersive power of lenses, using a yellow flame as the light source. Importantly, he replaced a prism with a diffraction grating, a device which greatly improved spectral resolution. He then independently rediscovered the Sun's spectral lines when he compared the flame spectrum with a solar spectrum produced by a prism.

Von Fraunhofer began systematic study and careful measurement of the wavelengths of black lines in the solar spectrum, eventually mapping over 570 of what are known as Fraunhofer lines. He designated the principal features with letters A to K, and weaker lines with lower case letters. Modern sunlight observation have detect many thousands of lines.

A spectral line is a dark or bright line in an otherwise uniform and continuous spectrum. They arise when electrons move between two energy levels in an atom and reflect the emission or absorption of this energy at particular frequencies, depending on the nature of the atoms. The atoms of different atoms (elements) and molecules produce unique spectral lines, enabling identification of which are present in an object. They can be observed across the electromagnetic spectrum, from gamma to radio waves. Lines can broaden or shift depending on both sub-atomic and larger scale effects.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed rev, www.en.wikipedia.org,