Solar Observations Throughout History

The Sun has always been the most important celestial object in our sky, and remains so to this day. All the major ancient civilisations worshiped a Sun god in some form; the Egyptians worshiped Re, the Babylonians worshiped Shamash, the early Greeks worshiped Helios and later Pheobus Apollo. The study of the Sun, planets and stars led the Greek philosophers to the first big step in astronomy of removing the earth from the centre of the universe, and suggesting it, along with all the other planets, revolved around the Sun. Since then solar observations have played a central role in many major scientific achievements throughout the ages.

Galileo used the Sun as the most obvious light source to test his new instrument in 1610. The development of this instrument, the telescope, would be a big breakthrough for physics and would be the main experimental driving force behind other important seventeenth century scientific advances. Kepler's observations of the Sun and planets would later lead to Newton's *Principia* (1687) and hence the theory of Gravitation was born. In his investigation of colours Newton (1672) used sunlight directed through a prism to discover the colour constituents of white light. Wollaston (1802) used sunlight through a narrow slit to discover dark lines, which he incorrectly identified as the borders between colours. Fraunhofer (1817) used a more sensitive setup to discover hundreds of these dark absorption lines which would later be named after him.

He made the important step of identifying the lines as a property of the sunlight itself, and not a property of the earth's atmosphere as previously thought (although some lines are due to absorption by oxygen molecules in the earth's atmosphere). His labelling system of the lines based on relative strengths, is still used today to some extent (for example, the sodium D doublet and ionized calcium H and K lines). The positions of these dark lines were soon equated with similar bright lines from earth based experiments. The jump to inferring the existence of certain elements in the Sun from their corresponding dark lines was soon made. Indeed in 1868 one such line led to the discovery of `helium' (named after the Greek god Helios) in the Sun 30 years before it was discovered on earth. The following years saw many new scientific theories with solar observations at their centre: Kirchhoff's law for radiation was based on fully explaining the Fraunhofer lines; the explanation of the Doppler shift originated from studying the Fraunhofer lines at the solar limb; the solar eclipse of 1919 provided confirmation of Einstein's Theory of Relativity.

The start of the twentieth century also saw the realisation of quantum physics and the atom. These theories would explain the origins of the dark Fraunhofer lines. The continuous solar spectrum was explained by Planck (1900), and further by Einstein (1905), by approximating the solar surface (photosphere) to a black body at a temperature of 5800 K. Bohr (1913), using Planck's ideas and Rutherford's atomic model, explained the atom in terms of discrete electrons orbit, where photons of light were emitted when any electron jumped from one orbit to another. Radiation from the photosphere with exactly the right amount of energy could be absorbed by an electron, exciting it to a higher orbit. The `flash spectrum' viewed during the initial stages of an eclipse could be explained as the re-emission of light as the electron decays to the lower orbit. Viewed against the brighter solar surface this would normally appear as dark lines in the solar spectrum. In the last few decades, the role of solar observations has moved into new areas. It still has a vital role to play in astronomy, as our only spatially resolvable star, in physics as the most stable and readily available example of plasma, the fourth state of matter, and in the commercial areas of military and communication.