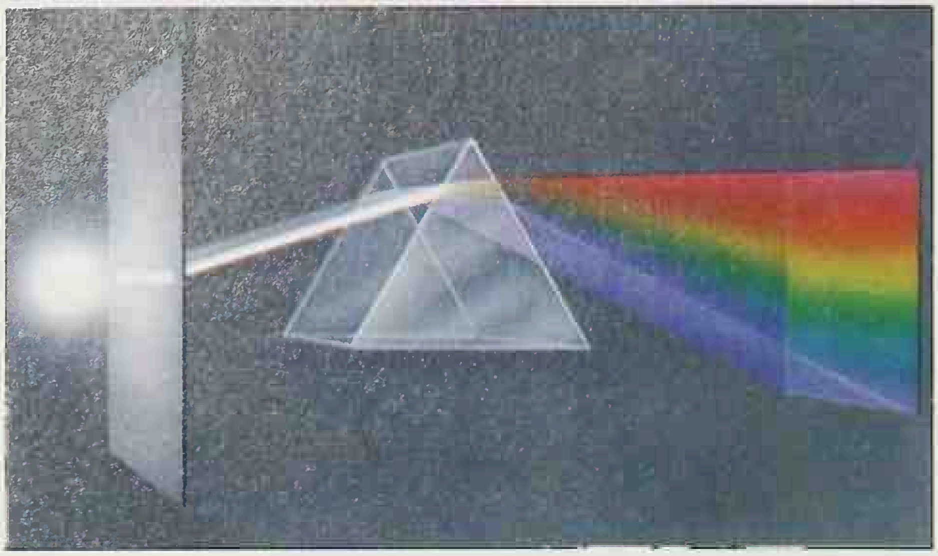
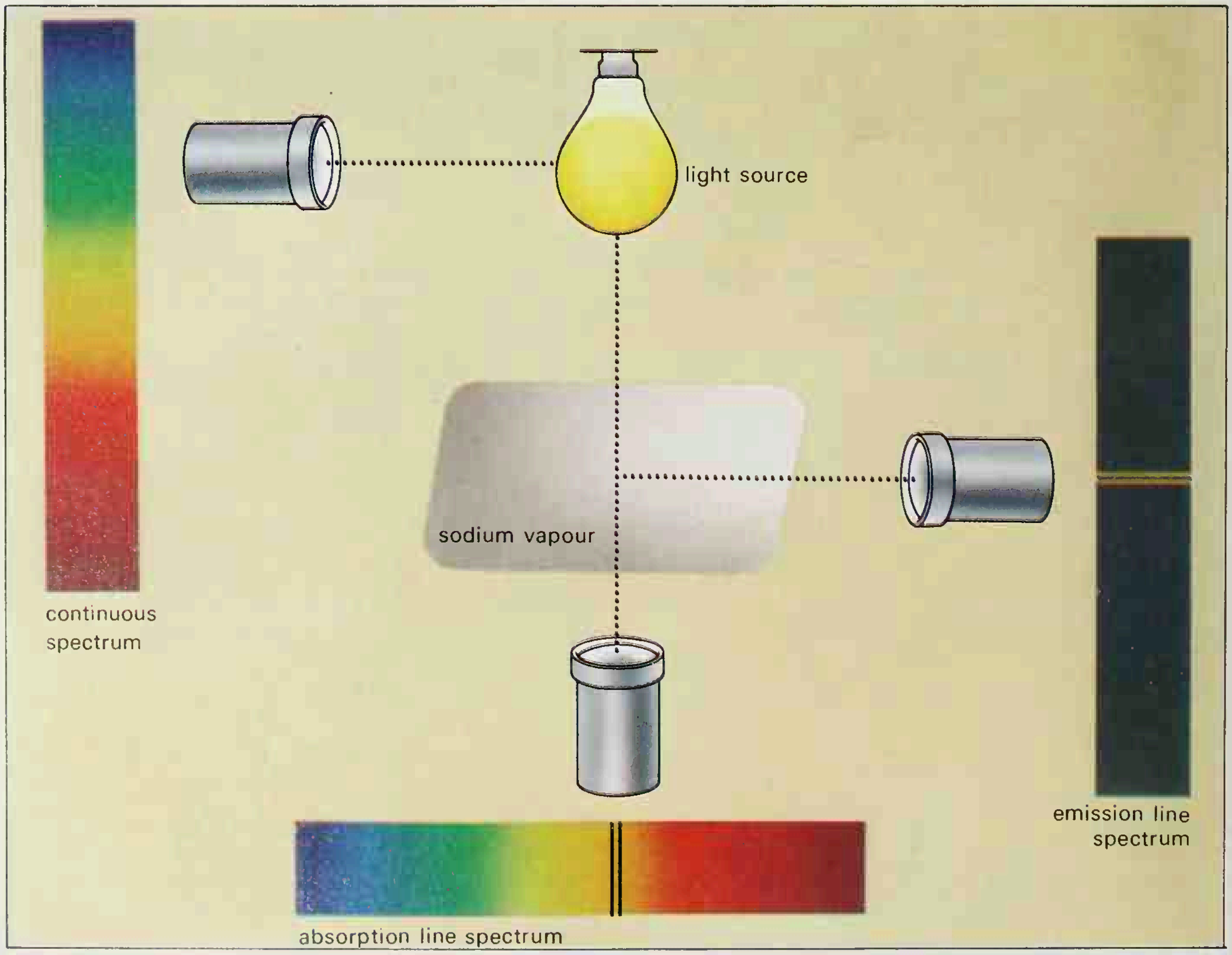


Fig. 3·2
When white light is passed through a prism it is split into many colours known as a spectrum. This rainbow-like effect was first studied in 1665 and 1666 by Sir Isaac Newton. Light of different wavelengths is deviated by varying amounts as it passes through the glass prism, red light being deviated least. This simple experiment shows how white light is a mixture of all colours between red and violet.

lines. These patterns were the fingerprints of the chemical elements, each set uniquely defining a certain chemical element. One such example was sodium, whose prominent lines lie in the yellow part of the spectrum giving a sodium lamp its characteristic yellow glow. Bunsen and Kirchhoff realized that bright lines represented the emission of energy. Therefore, if an emitting system is losing energy and yet remains bright, there must be a continuous supply of energy, in their case the hot Bunsen flame. It is now known that this emission of light is caused by atoms of the gas being raised to what is referred to as an 'excited state' by being supplied with energy. The atoms return to their ground state and emit light in the process. The amount of energy input to the gas and so the degree of excitation of the atoms determines the number of bright lines emitted in a pattern. Hence, a bright line emission spectrum reveals not only the chemical elements present in the gas but also the degree of excitation of the atoms. This must have some bearing on the local energy environment of the atoms, that is, the temperature.

Kirchhoff, puzzled by the difference between the solar spectrum and the spectra of hot gases, performed further experiments. He found that if he heated a solid, it gave off a bright continuous spectrum. If he then placed a sodium flame between the incandescent solid and his spectroscope he saw a continuous spectrum crossed with dark lines, whose positions in the spectrum were identical to where the bright lines of a sodium flame would appear. This crucial experiment marked the beginning of astrophysics. Astronomers could now scrutinize stellar spectra and thereby determine the chemical composition of stars. The science of astronomical spectroscopy was born. Kirchhoff realized that the dark lines are absorption lines caused by the light from a continuous spectrum passing through a gas at a lower (though perhaps still very high) temperature. The light is now absorbed by the atoms of the gas, the patterns of the lines and number of lines in the pattern revealing the chemical composition and degree of excitation (temperature) of the atoms present. In 1864, using the new technique of stellar spectroscopy, nine elements were identified in the star Aldebaran (α Tauri), and progress was swift.

Spectroscopy also brought a new dimension to distance measurement. Due to the work of Christian Doppler and Hippolyte Fizeau it was found that the



A demonstration of Kirchhoff's Laws of spectral analysis, whereby the continuous spectrum from the hot source has superimposed dark absorption lines of the cooler sodium vapour, which itself emits a bright line emission spectrum characteristic of the elements of the vapour. The absorption lines and emission lines occur at identical wavelengths.