Figure 3·1 shows the relative transmission of the UBV system.

Further standard photometry magnitudes are R (red), I (infrared) and the more recent infrared magnitudes of J, K, L, M and N. The latter five are selected to have peak transmission in the narrow windows where infrared radiation is least absorbed by the atmosphere.

By observing in many colours, a useful parameter known as the **colour index** may be obtained. This is defined as the difference between magnitudes measured at two different colours. With the UBV system, two very widely used colour indices are (U-B) and (B-V). These are closely related to a star's luminosity and temperature, both of which are intrinsic parameters astronomers wish to know to learn more about stellar evolution.

Nuclear reactions deep in the interior of a star provide energy which is transported by a very slow process to the outer layers. This energy is eventually radiated into space and the rate at which it is emitted is known as the **luminosity**, L, of the star. This depends mainly on the size and surface temperature of the star, increasing in proportion to the radius, R, of the star squared and to the fourth power of the temperature, T. We can write this mathematically as

$$L \propto R^2T^4.$$

Luminosity is the intrinsic property which we would like to determine, but how bright the star appears to us obviously depends on its distance. This is usually unknown and so we begin by classifying the stars according to apparent brightness. The apparent brightness is the extent to which the power output of the star has been diluted by the distance the light has travelled on its journey to the Earth.

To compare the luminosities of stars we need to be able to determine their distances. Usually, this is impossible to do by a direct means, as will be discussed later. However, accepting this difficulty, it has been possible to obtain distances and thus luminosities. Another term which is often used for luminosity is **absolute magnitude**. This is defined to be equal to the apparent magnitude if the star in question is viewed from a distance of 10 pc. This then classifies the intrinsic brightness of stars on the same scale. (Ten pc is chosen because it fits in conveniently with the way stellar distances are measured.) Absolute magnitudes are written with a capital M, any subscript having the same meaning as before – for example, M_v is the absolute magnitude through a V filter. Absolute magnitudes range from −9 for the most luminous down to +15 for dark dwarf stars. As with apparent magnitudes, an increasing negative number indicates a more luminous star.

A most important relationship may be obtained from the apparent and absolute magnitudes. This is called the **distance modulus**. It is given by

$$m - M = 5 \log d - 5;$$

(where 'log' means 'the logarithm of'). Obviously, if the distance d is known, then this equation enables the absolute magnitude, M, to be deduced from a measurement of the apparent magnitude, m. It was from the use of the direct distance-determining technique of trigonometric parallax that the absolute magnitudes of nearby stars were obtained, setting the basis for the most important diagram in astronomy, the Hertzsprung-Russell (H-R) diagram holding the innermost secrets of stellar evolution.

For the millions of other stars whose distances can not be determined by direct studies because they are too great, this equation is the key. It will be seen later that the temperature of a star may be deduced from its spectrum; the absolute magnitude can also be estimated and by application of the equation the distance may be found from the measured value of the apparent magnitude. The distance modulus determination is a crucial means of finding the distances to other galaxies.

A word of caution; in the above determination of apparent magnitude no account has been taken of the presence of absorbing matter in the space between the stars. Astronomers now know that interstellar dust abounds in space and this dims the light from distant stars, making the star appear fainter than it really is. By measuring the interstellar reddening of the stars' spectra a correction factor may be applied. The effects of dust in the Galaxy and reddening are described on page 184. We shall now investigate the stars in the sky and learn of their differing and often exotic features as they pour forth energy to brighten our night sky.

Stars as radiating bodies

By studying the radiation from stars, astrophysicists have been able to deduce such properties as stellar temperatures, sizes and compositions. They do this by a process called SPECTROSCOPY, the detailed wavelength analysis of radiation; in our case the light emanating from the star. This light energy was originally supplied by nuclear reactions deep in its core. It very gradually filters outwards through the gas of which the star is composed. Eventually, the light energy escapes from the surface region with a wavelength pattern or **spectrum** (Fig. 3·2) which is governed by the temperature, density and chemical composition of the surface layer.

Typical stellar spectra are called absorption-line spectra, that is, they consist of a continuous background of light crossed by dark absorption lines in particular wavelengths. In 1802, William Wollaston, an English chemist, used a prism to split up the light from the Sun into its respective colours. He found that the bright continuous spectrum was crossed by a few dark lines. Joseph Fraunhofer, in 1814, made more detailed measurements and found that the solar spectrum was literally full of dark lines, totalling over 600. It was left to Robert Bunsen and Gustav Kirchhoff to make a brilliant analysis using the spectroscope – a device invented for detailed analysis of a spectrum by using a prism to split up the light, the resulting colours being viewed through a telescope. By a series of elegant experiments, they found that chemical elements when burned did not give a continuous bright spectrum like the Sun, but a series of separate bright lines. They also showed that different elements emitted different patterns of bright