GLOSSARY OF TERMS

Absorption line: A dark line formed at a particular wavelength when an electron jumps from a lower to a higher energy level in an atom while absorbing light from a bright, continuous background source.

Angstrom Å: A unit of length equal to 10^{-10} m, or 10^{-8} cm, or 0.1nm.

Atomic spectra: Transitions between atomic energy levels within atoms that lead to the absorption or emission of radiation in a series of sharply defined lines, corresponding to fixed wavelengths representing radiation quanta of definite energies. There are six named series of lines for hydrogen:

- Lyman far ultraviolet
- Balmer series seen at visible wavelengths
- Paschen infrared
- Brackett far infrared
- Pfund far infrared
- Humphreys far infrared

Be-type stars: B-type stars with bright emission lines of hydrogen, which are superimposed on the normal dark absorption lines, e.g., Gamma Cassiopeiae.

Blackbody radiation: The emission of radiation from incandescent material independent of the chemical composition and physical nature of the material. A black body is both a perfect absorber and emitter of radiation. Any radiation is absorbed without loss due to reflection or transmission.

Blaze angle: In a grating the faces of the grooves are cut at a constant angle to the plane of the original surface of the grating material. The angle of inclination of the grooves is known as the blaze angle. Blazing concentrates the diffracted spectrum in a specific order and wavelength range.

B–V color index: The color or measure of a star's color. B–V may need to be corrected for interstellar reddening before an accurate temperature value can be estimated. Estimation is done by observing the star's magnitude through two different filters from the UBVRI Johnson–Cousins filters system, where U is sensitive to ultraviolet light, B is sensitive to blue light, V is

sensitive to green-yellow light, R is sensitive to red light, and I is sensitive to infrared light. The difference in magnitude found is the B–V color index. The more negative the color index, the bluer (the hotter) the object is, e.g., Rigel is –0.03. (Its B magnitude is 0.09 and its V magnitude is 0.12; so B–V = –0.03.) The more positive the color index, the redder (the cooler) the object is, e.g., the Sun +0.66.

Chromosphere: A region of the sun's atmosphere lying above the photosphere with a temperature of 6,000–20,000K.

Color magnitude diagram: A graph showing significant correlations between a star's color and its luminosity. Color is related to effective temperature and spectral class. See *HR diagram*.

Continuous spectrum: Incandescent solids emit a spectrum consisting of all wavelengths in a given range (a continuous spectrum), without any absorption or emission lines.

Continuum: Part of the spectrum that has neither absorption or emission lines with only a smooth wavelength distribution.

Corona: The outermost region of the sun's atmosphere with a temperature of around 2,000,000K.

Declination (DEC δ): A coordinate used with right ascension in the equatorial coordinate system analogous to latitude, expressed in degrees (°), minutes (′) and seconds (″) of arc. Objects north of the celestial equator have + declinations, and those south have – declinations. Objects on the celestial equator have a declination of 0°, and the poles ±90°.

Diffraction: This occurs when a wavefront passes through narrow slits and at sharp edges. It is due to the wave nature of light.

Diffraction grating: Invented by American astronomer David Rittenhouse in 1785. The conventional grating consists of a series of closely spaced parallel lines scored onto the surface of a metal or glass. Spectra are produced by diffraction of the wavefront at the grating surface. The dispersion of spectral lines through a grating is linear, whereas through a prism it is nonlinear.

Dispersion: The ability of a grating or prism to separate the visible wavelengths of radiant energy into a spectrum measured in Å/mm or nm/mm.

Doppler broadening: The broadening of absorption or emission lines by the thermal motion of atoms.

Doppler effect: A change of frequency of electromagnetic radiation due to relative motion between the observer and the source along the observer's line of sight.

Doppler shift: The change in wavelength observed when a body emitting light is moving away from (red shifted) or toward (blue shifted) along the observer's line of sight.

Echelette/Echelle gratings: A very accurately ruled reflection grating with about 1,000 lines cm^{-1} and a broad groove such that about 75% of the reflected light is concentrated in one order.

An echelle grating is a coarse form of echelette grating with fewer fine lines that are more widely spaced. This arrangement gives a higher resolution over a narrower waveband such that 50 lines cm^{-1} can give a resolving power comparable to 10,000 lines cm^{-1}.

Electromagnetic radiation: Radiation that carries energy through space in a vacuum at the speed of light.

Electromagnetic spectrum: Considered to consist of the region of radiant energy ranging from wavelengths of 1×10^{-10} cm to 10m, that is gamma rays–xrays–ultraviolet–visible–infrared and radio waves.

Electron: The Greek word for amber, also called a negatron, a negatively charged elementary particle theorized by G. Johnstone Stoney in 1874 and discovered by J.J. Thomson in 1897:

Mass = $9.109{,}534 \times 10^{-31}$ kg
Charge = $1.602{,}189 \times 10^{-19}$ C
Spin quantum number = 1/2

Electron volt: The eV is a unit of energy equal to the energy gained by an electron when it accelerates through a potential difference of 1 V in a vacuum equal to 1.602×10^{-19} joules.

Emission line: A bright line formed at a particular wavelength when an electron jumps from a higher to a lower energy level in an atom by emitting a photon of a specific wavelength. See *Be-type stars.*

Energy level: A quantity of energy associated with a bound electron orbiting around an atomic nucleus. An increase in energy will shift the electron to a higher energy level within an atom.

Excitation: An atomic process where an atom or ion is raised to a higher energy state by an electron jumping from a lower to a higher energy level.

Flash Spectrum: An emission line spectrum of the solar chromosphere seen just before and after totality of an eclipse of the sun.

Forbidden lines: Lines not found in spectra under normal terrestial conditions, but are observed in certain astronomical spectra such as emission nebulae, because under normal laboratory conditions such atoms would be deexicited by collisions with other atoms before they had time to radiate.

Fraunhofer lines: Dark absorption lines in the solar spectrum first observed by William Wollaston in 1802. First studied in detail by Joseph Von Fraunhofer in 1814, he catalogued over 500 lines and labelled the more prominent ones with letters.

Frequency (*v*): Refers to any periodic phenomenon, particularly to the number of cycles per unit time, measured in Hertz and varies inversely with wavelength.

Ground state: The lowest possible energy level for a given atom or molecule.

HD: Named after Henry Draper, HD is a catalog of spectral types and positions of 225,300 stars numbered in right ascension for 1900 epoch. Compiled by Annie Jump Cannon and co-workers at Harvard College Observatory between 1918 and 1924, each star is assigned with its own HD number. Stars in the range 225,301–359,082 are from the Henry Draper Extension catalog denoted HDE published from 1925 through 1936 and 1949.

HR diagram: Hertzsprung–Russell diagram in which a star's absolute magnitude is plotted against its spectral type.

Intensity: The amount of radiation received from an object. Optical astronomers prefer the term brightness.

Ion: Molecules and atoms that have acquired a positive or negative charge through losing or gaining one or more electrons.

Ionization: A process in which a neutral atom or molecule is given charge by removal of an electron from an atom, ion or molecule by collisians with other atoms or electrons. Because of the high temperatures in stars, much of the matter present is in an ionised state.

Kelvin: A unit of thermodynamic temperature, or the fraction 1/273.16 of the thermodynamic temperature of the triple point of water, denoted by the symbol K. 0 K = −273.16°C absolute zero.

Light: A specific part of the electromagnetic spectrum covering the visible region normally associated with human vision from violet 380.0 nm to red 780.0 nm.

Light year: The distance light travels in a vacuum in 1 year. Numerically equal to:

63,241 au
0.306 pc
9,460,730,472,580.8 km

Luminosity: The total energy radiated per second by a star expressed in joules per second, which is determined by its surface area and surface temperature.

Luminosity class: Indicates whether a star is a dwarf, giant, or a supergiant as follows:

Ia	Bright supergiants
Ib	Supergiants
II	Bright giants
III	Giants
IV	Sub giants
V	Main sequence dwarfs

For the spectrum descriptors, the suffix is placed after the Luminosity class descriptor, i.e., Iae.
Suffixes for emission lines:

e	**Emission line star**
em	**Emission by metal lines**
ep	**Peculiar emission**
eq	**P Cygni emission**
er	**Reversed emission**
f	**Helium and Nitrogen emission**

Other suffixes:

k	**Interstellar lines**
m	**Strong metallic absorption**
n	**Nebulous diffuse lines**
nn	**Very diffuse lines**
p = pec	**Chemically peculiar spectrum no Luminosity class assigned**
s	**Sharp lines**
si	**Silicon star**
v	**Variation in the spectrum not caused by velocity effects**
wk	**Weak lines**

Magnitude: **A logarithmic measure of the brightness of an object.**

Apparent magnitude (*m*) is a measure of its relative brightness as if seen by an observer on Earth. For example, the apparent magnitude of the sun is –26.74.

Absolute magnitude (*M*) is the apparent magnitude it would have if it were at a standard luminosity distance of 10 parsecs from the observer, allowing the true brightness to be compared without regard to distance. The absolute magnitudes of most stars are between –5 and +15.

Main sequence: **A diagonal region in the Hertzsprung–Russell diagram that contains about 90% of all stars. Stars on the main sequence are those converting hydrogen into helium in their cores.**

Main sequence star: **One of the classes of stars that increase in size, temperature, and brightness in a regular progression, e.g., the Sun. Its Luminosity class suffix is V in the MK spectral classification (see below).**

Metallicity: The proportion of matter in an object made up of chemical elements other than hydrogen or helium. Astronomers label all heavier elements "metal." For example, a star rich in carbon would be called "metal rich" even though carbon is not a metal.

MK system: The Morgan–Keenan system for classifying stellar spectra. Introduced in 1943.

Monochromatic light: Light of one wavelength, e.g., a green laser beam has a wavel length of 532 nm.

Nanometer (nm): A unit of length. 1 nm = 10^{-9} m = 10 Å.

Nuclear fusion: A process by which stars generate energy. The nucleus of an atom fuses with the nuclei of other atoms, producing heavier atoms and releasing large amounts of energy. In the Sun, hydrogen is converted into helium.

Objective prism: A small-angle prism placed in front of a telescope objective to disperse each star image into its spectrum.

Photon: Electromagnetic energy is produced in discrete small quantities called photons. Photons produced at a particular frequency all have the same energy. The amount of energy present depends on the frequency of the radiation.

Photosphere: The bright visible region of a star's atmosphere where spectral lines are produced.

Prism: A transparent piece of glass with flat polished surfaces that refract light. The dispersion is nonlinear, blue light is bent more than red light. There are four types of dispersive prism: triangular, Abbe, Porro, and Porro–Abbe.

Radial velocity: The velocity of a star along the line of sight of an observer calculated from the Doppler shift in the spectral lines. If the star is receding, there will be a red shift in its spectral lines, and the radial velocity will be positive. An approaching star will produce a blue shift, and the radial velocity will be negative, measured in KMS^{-1}.

Rest wavelengths: Those wavelengths measured from a source at rest in the laboratory (as opposed to Doppler shifted wavelengths from a moving source).

Right ascension (RA α): A coordinate used with declination in the equatorial coordinate system comparable to longitude, expressed in hours (h), minutes (min) and seconds (s), from 0 to 24 h. Measured eastward from the vernal equinox, uniquely identifying the position of a star in the sky. The effect of precession means it must be specified with reference to a particular epoch, currently J2000 January 1, 2000, at 12.00 UT1. The prefix J indicates a Julian epoch.

Spectral line: A radiative Feature observed in absorption (dark) or emission (bright) at specific frequencies or wave lengths, produced by atoms or ions as they absorb or emit light.

Spectral type: The different groups into which stars may be classified according to the characteristics of their spectra. The surface temperature of a star may often be inferred from its spectral type, as follows:

W	30,000–70,000 K
O	28,000–50,000 K
B	9,900–28,000 K
A	7,400–9,900 K
F	6,000–7,400 K
G	4,900–6,000 K
K	3,600–4,900 K
M	2,000–3,600 K
C-R	2,800–5,100 K (Carbon star equivalent of late G/early K)
C-N	2,600–3,100 K (Carbon star equivalent of late K/early M)
S	<2,000 K (Late-type giant star showing zirconium oxide bands)
L	1,300–2,000 K (Dwarf with spectrum showing metal hydrides and alkali metals)
T	770–1,000 K (Dwarf with prominent methane bands in its spectrum)
Y	<700 K (Hypothetical convincing examples have yet to be observed)

In general, the temperature of a star is estimated from its B–V color index (after correction for any reddening caused by the interstellar medium).

This works because stars radiate approximately like blackbody emitters. Most of the temperatures quoted in the properties tables are accurate to within ±10%. The temperatures of the cooler stars are estimated from their infrared spectra, because these stars are very faint in the B and V bands.

Spectrogram: A photographic or digital image of a spectrum.

Spectral line: A radiative feature observed in absorption (dark) or emission (bright) at specific frequencies or wave lengths, produced by atoms or ions as they absorb or emit light.

Spectrograph: An instrument that splits light or other electromagnetic radiation into its individual wavelengths and records the resulting spectrum photographically or digitally.

Spectroheliograph: An instrument used to image the sun at particular wavelengths to observe features normally lost in the total spectrum of radiation emitted, such as the calcium H 396.8 nm and K 393.4 nm and the hydrogen alpha 656.3 nm lines.

Spectrohelioscope: The optical counterpart of a spectroheliograph.

Spectrometer (optical): An instrument that produces a spectrum, which can be measured by scanning along its dispersion.

Spectrophotometer: A sophisticated spectrometer for studying infrared, visible, and ultraviolet regions, with devices for automatic measurement and recording of spectra.

Spectroscope: A device usually consisting of a prism or diffraction grating that can disperse a beam of light into its component wavelengths.

Spectroscopic binary: A binary star in which the orbital motions of the components show detectable variations in radial velocity, revealed by changes in the Doppler shift of their spectral lines.

Spectroscopic parallax: A method of determining stellar distances for a group of stars based on their magnitudes and spectral types.

Spectroscopy: The study and interpretation of spectra that can reveal information about the chemical abundances, temperature, radial velocity, rotation, magnetic field, steller density and pressure, etc. of a light source.

Spectrum: An array of six colors (violet–blue–green–yellow–orange–red, or rainbow) obtained by dispersing light through a grating or prism.

Speed of light (*c*): Measured in a vacuum, *c* has the value 299,792,458 m/s. (The speed of light is now fixed so this is, in effect, a definition of the meter).

Star: A luminous ball of plasma that creates and emits its own radiation through nuclear fusion, by combining two or more atomic nuclei into a more complex, heavier nucleus in the stellar core.

Stark–Lo Surdo broadening effect: Co-discovered in 1913, this is the shifting and splitting of a spectral line by an electric field and is responsible for pressure or broadening of a spectral line by charged particles.

Temperature: Astronomical temperatures are usually measured from spectroscopic observations. Astronomical bodies do not generally have a uniform temperature distribution, So they do not exactly obey the temperature laws, hence there are different types of temperature characterising a particular property of the body with slightly different values, effective-colour-brightness-ionization and excitation temperatures.

Ultimate/resonance lines: The last lines to disappear in the spectrum of an element when the quantity of the element is diminished indefinitely.

Wavelength: The distance from crest to crest or trough to trough of an electromagnetic or other wave. Wavelength is related to frequency. The longer the wavelength, the lower the frequency.

Zeeman effect: Observed when atoms are subjected to a powerful magnetic field, resulting in a spectral line being split into several components. Measured by calculating the difference between right and left hand polarization across the spectral line.

FURTHER READING

Aller, L. H., *Atoms, Stars and Nebulae*, Third edition, Cambridge University Press, 1991.

Bell Burnell, J. S., S. F. Green, B. W. Jones, M. H. Jones, R. J. A. Lambourne, J. C. Zarnecki, *An Introduction to the Sun and Stars*, Cambridge University Press, 2003.

Brandt, J. C., R. D. C. Chapman, *Introduction to Comets*, Cambridge University Press, 1982.

Daish, C. B., *Light to Advanced and Scholarship Level*, The English Universities Press, 1963.

Gray, D. F., *The Observation and Analysis of Stellar Photospheres*, Third edition, Cambridge University Press, 2005.

Hearnshaw, J., *The Analysis of Starlight*, Cambridge University Press, 1990.

Hearnshaw, J., *Astronomical Spectrographs and Their History*, Cambridge University Press, 2009.

Hentschel, K., *Mapping the Spectrum*, Oxford University Press, 2002.

Herzberg, G., *Atomic Spectra and Atomic Structure*, Dover, New York, 1944.

Hynek, J. A., *Astrophysics*, McGraw-Hill, New York, 1951.

Inglis, M., *Observer's Guide to Stellar Evolution*, Springer, 2003.

Inglis, M., *Astrophysics Is Easy!*, Springer, 2007.

Kaler, J., *Stars and Their Spectra*, Cambridge University Press, 1989.

Kaler, J., *Extreme Stars*, Cambridge University Press, 2001.

Kaler, J., The Cambridge Encyclopedia of Stars, Cambridge University Press, 2006.

Kitchen, C. R., *Optical Astronomical Spectroscopy*, Institute of Physics Publishing, 1995.

Krogdahl, W. S., *The Astronomical Universe*, Macmillan, 1952.

Lang, K.R., The Cambridge Encyclopedia of the sun, Cambridge University Press, 2001.

Loden, K., L. O. Loden, U. Sinnerstad, *Spectral Classification and Multicolour Photometry*, International Astronomical Union, 1966.

Malpas, D. B., *The Bright Star Spectra Index*, Draft 9205.1, Rainbow Optics newsletter, July 3, 1995.

Martin, J., A mathematical method for identifying lines in stellar spectra, *J. Br. Astron. Assoc.* 109(1), 1999, 22–24.

Moore, C. E., *A Multiplet Table of Astrophysical Interest*, NBS Technical Note, 36, United States Department of Commerce, Revised edition, 1972.

Motz, L., A. Duveen, *Essentials of Astronomy*, Blackie, London, 1966.

Noakes, G. R., *Textbook of Light*, Macmillan, 1946.

North, G., *Advanced Amateur Astronomy*, Second edition, Cambridge University Press, 1997.

Palmer, C., *Diffraction Grating Handbook*, Richardson Grating Laboratory, Rochester, NY, 2000.

Robinson, K., *Spectroscopy: The Key to the Stars*, Springer, London Ltd., 2007.

Sawyer, R. A., *Experimental Spectroscopy*, Dover, New York, 1963.

Scheiner J., ***A Treatise on Astronomical Spectroscopy*****, Ginn, London, 1898.**
Smith-Dibon, R., ***Starlist 2000*****, Wiley, 1992.**
Straughan, B. P., S. Walker, ***Spectroscopy*****,** ***Volume 3*****, Chapman & Hall, 1976.**
Tennyson, J., ***Astronomical Spectroscopy – An Introduction to the Atomic and Molecular Physics of Astronomical Spectra*****, Imperial College Press, 2005.**
Thackeray, A. D., ***Astronomical Spectroscopy*****, Eyre & Spottiswoode, London, 1963.**
Tonkin S. F., D. Randell, J. Martin, N. Glumac, S. J. Dearden, D. E. Mais, T. Kaye, ***Practical Amateur Spectroscopy*****, Springer, London Ltd., 2002.**
Whiffen, D. H., ***Spectroscopy*****, Second edition, Longmans, London, 1966.**

Index