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## Stellar spectra

A star's spectrum contains information about its temperature, chemical composition, and intrinsic luminosity. Spectrograms secured with a slit spectrograph consist of a sequence of images of the slit in the light of the star at successive wavelengths. Adequate spectral resolution (or dispersion) might show the star to be a member of a close binary system, in rapid rotation, or to have an extended atmosphere. Quantitative determination of its chemical composition then becomes possible. Inspection of a high-resolution spectrum of the star may reveal evidence of a strong magnetic field.

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### Line spectrum

[Stellar colours](#)

Spectral lines are produced by transitions of electrons within atoms or ions. As the electrons move closer to or farther from the nucleus of an atom (or of an ion), energy in the form of light (or other radiation) is emitted or absorbed. The yellow D lines of sodium or the H and K lines of ionized

hydrogen (seen as dark absorption lines) are produced by discrete quantum jumps from the lowest energy levels (ground states) of these atoms. The visible hydrogen lines (the so-called Balmer series; see spectral line series), however, are produced by electron transitions within atoms in the second energy level (or first excited state), which lies well above the ground level in energy. Only at high temperatures are sufficient numbers of atoms maintained in this state by collisions, radiations, and so

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involve higher energy levels that tend to be more sparsely populated than the lower levels. Another



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### How Do We Know How Far Away the Stars Are?

"Star light, star bright, first star I see tonight"...is trillions of miles away.

involve higher energy levels that tend to be more sparsely populated than the lower levels. Another factor is that the general “fogginess,” or opacity, of the atmospheres of these hotter stars is greatly increased, resulting in fewer atoms in the visible stellar layers capable of producing the observed lines.

Stellar radii

The **continuous** (as distinct from the line) spectrum of the **Sun** is produced primarily by the

Average stellar values

photodissociation of negatively charged hydrogen ions ( $H^-$ )—i.e., atoms of hydrogen to which an

Stellar statistics

extra electron is loosely attached. In the Sun’s atmosphere, when  $H^-$  is subsequently destroyed by

Hertzsprung-Russell diagram

photodissociation, it can absorb energy at any of a whole range of wavelengths and thus produce a

Estimates of stellar ages

continuous range of absorption of radiation. The main source of light absorption in the hotter stars is

the photoionization

luminosity

## Spectral analysis

Mass and density measurements

Variable stars

The physical processes behind the formation of stellar spectra are well enough understood to permit

Classification

determinations of temperatures, densities, and chemical compositions of stellar atmospheres. The

Stars studied

most extensively is, of course, the Sun, but many others also have been investigated in

detail.

Explosive variables

Peculiar variables

The general characteristics of the spectra of stars depend more on temperature variations among the

Stars than

on their chemical differences. Spectral features also depend on the **density** of the

Stellar atmospheres

absorbing atmospheric matter, and density in turn is related to a star’s surface **gravity**. **Dwarf stars**,

Stellar interiors

with great surface gravities, tend to have high atmospheric **densities**; **giants** and **supergiants**, with

Distribution of matter

low surface gravities, have relatively low densities. **Hydrogen** absorption lines provide a case in point.

Source of stellar energy

Normally, an undisturbed atom radiates a very narrow line. If its energy levels are perturbed by

charged particles

passing nearby, it radiates at a wavelength near its characteristic wavelength. In a

Star formation and evolution

hot gas, the range of disturbance of the hydrogen lines is very high, so that the spectral line radiated

Birth of stars and evolution to

by the whole mass of gas is spread out considerably; the amount of blurring depends on the density

of the gas in a known fashion. Dwarf stars such as **Sirius** show broad hydrogen features with

the main sequence

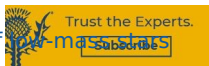
extensive “wings” where the line fades slowly out into the background, while supergiant stars, with

Subsequent development of

less-dense atmospheres, display relatively narrow hydrogen lines.

Later stages of evolution

Evolution of high-mass stars



Origin of the chemical elements

Evolution of high-mass stars

End states of stars

White dwarfs

Neutron stars

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