THE STELLAR EVOLUTION OF G-TYPE STARS

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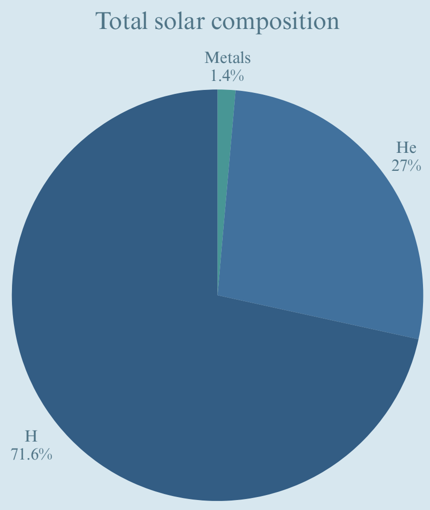
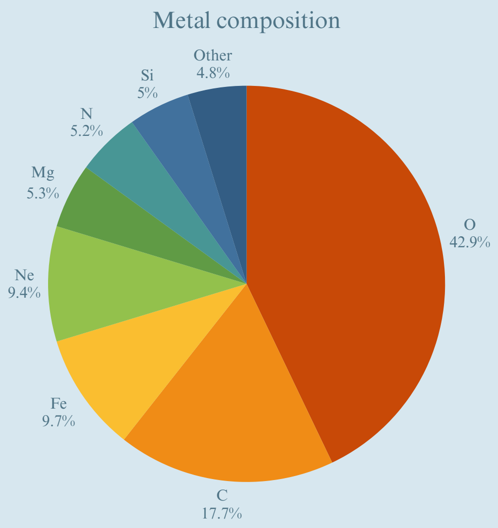
Introduction

Stars are self-gravitating spheres of ionised plasma in hydrostatic equilibrium, where radiation pressure and gas pressure counteract gravitational attraction. Their energy originates from thermonuclear fusion processes that convert hydrogen into helium in the nucleus, releasing photons, neutrinos and radiation ranging from gamma rays to radio waves. This mechanism not only ensures the structural stability of the star, but also determines its evolutionary trajectory. However, when the central hydrogen is depleted, the balance between pressure and gravity is broken, giving way to new phases.

Relevant features

Stars have various characteristics that allow us to study their nature. Their colour depends on their temperature: the hottest are blue and the coldest are red, while the Sun, at 5,800 K, is yellow. Apparent magnitude measures brightness as seen from Earth; it is an inverse scale in which lower values mean greater brightness. There is also absolute magnitude, which reflects actual luminosity. Mass is a key factor that determines the size, colour, lifespan and evolution of a star; it varies from 0.08 $M_\odot$ (the lower limit for a star) to around 200 $M_\odot$, and the more massive a star is, the shorter its life. The chemical composition is mainly hydrogen and helium, with traces of other elements, and due to the high temperature they are in a plasma state; their analysis is achieved through spectra. Finally, their size varies greatly: most are comparable to the Sun, but during their evolution they can expand into giants and then collapse into white dwarfs, neutron stars or black holes.

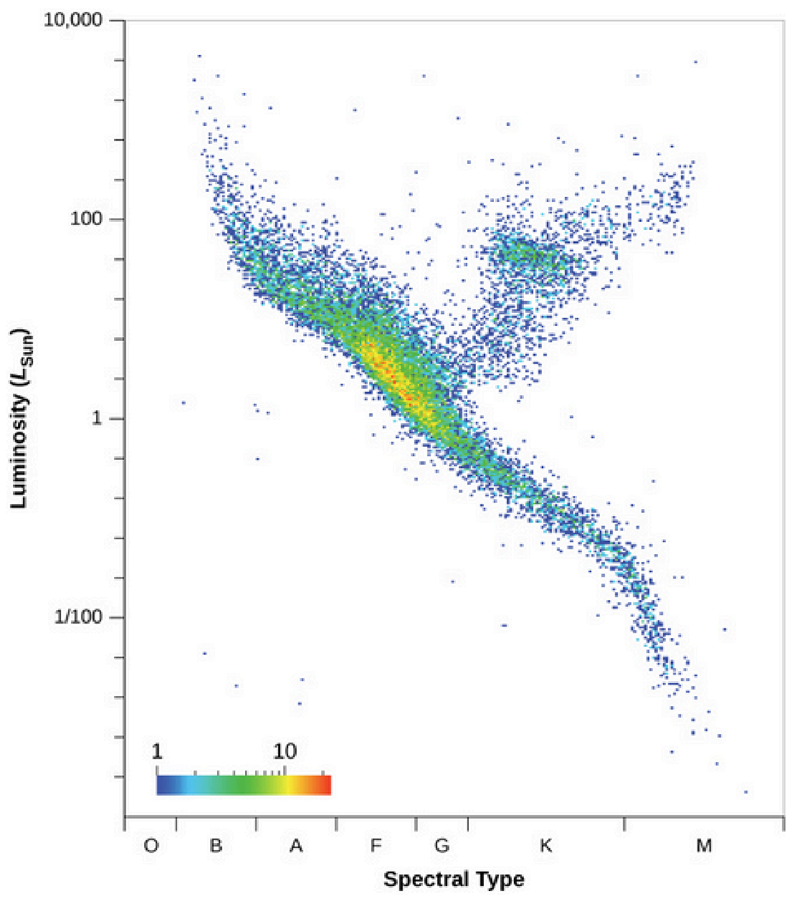




Star classification

The stellar classification is based on the analysis of the spectrum of starlight, which allows us to determine properties such as chemical composition, temperature and surface gravity. It was developed in two stages: the first, at Harvard in the early 20th century, with spectral classification; and the second, in 1943 at Yerkes, which added classification by luminosity. There are currently seven spectral classes (O, B, A, F, G, K and M), ordered from hottest and bluest (type O, up to 50,000 K) to coldest and reddest (type M, around 2,200 K). The Sun, for example, is a G2 type star. The luminosity classes complement this classification, as stars with the same temperature can have different sizes and brightnesses depending on their evolution. They are divided into eight categories ranging from hypergiants (0) to white dwarfs (VII), including supergiants, giants and main sequence dwarfs.

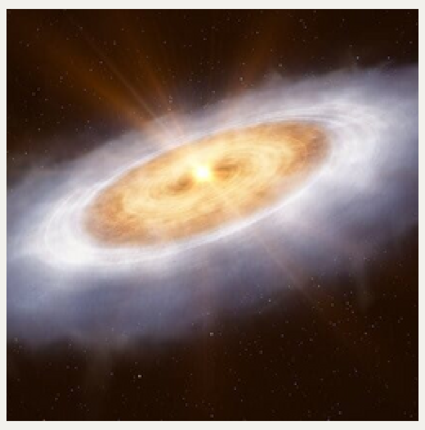
The Hertzsprung-Russell (HR) diagram combines the two classifications and shows the relationship between temperature and luminosity. Three main zones are identified: the main sequence (where most stars are found), the giant and supergiant region, and the white dwarf region. The diagram also allows other parameters to be deduced, such as the radius, mass, and age of the star, since the most luminous stars are also the most massive and have shorter lifespans, while the least luminous stars live much longer.



Star formation

Nebula (molecular cloud)

Stars form within molecular clouds, cold (10–20 K) and dense regions of the interstellar medium, rich in hydrogen, helium, cosmic dust and molecules such as CO, H_2O and CN. When a disturbance, such as density waves, galactic interactions or nearby supernovae, breaks the hydrostatic equilibrium of the cloud, a gravitational collapse occurs, overcoming the internal thermal pressure. The cloud fragments into smaller nuclei, each with sufficient mass to form a star. During this process, gravitational potential energy is transformed into infrared radiation, which facilitates contraction and prevents excessive heating. This is also how open star clusters are formed, where stars share the same age and origin.



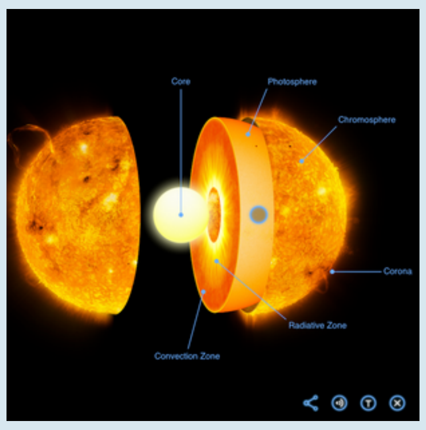
Proto-star

Each fragmented nucleus becomes a proto-star, a contracting structure surrounded by an accretion disc, which allows for the gradual accumulation of mass. The temperature and pressure of the nucleus increase, and stellar winds and an intense magnetic field appear, characteristic of T Tauri stars. When the core reaches ~10 million degrees, hydrogen nuclear fusion reactions begin, establishing hydrostatic equilibrium and transforming the protostar into a mature star. The surrounding disc can generate planets, while the loss of angular momentum regulates the dynamics of the emerging planetary system.

Main sequence

Internal structure

Sun-like stars have a layered structure composed of a core, mantle and atmosphere. In the core, nuclear fusion of protons into helium generates energy, maintaining hydrostatic equilibrium thanks to the counterbalance between gravity and radiation pressure. The mantle transports this energy to the outside through radiation and convection, regulating the central temperature and stabilising the stellar density. The atmosphere constitutes the interface with space, where magnetic fields and convective flows generate phenomena such as solar flares and influence the dynamics of the surface plasma.



Stellar atmospheres

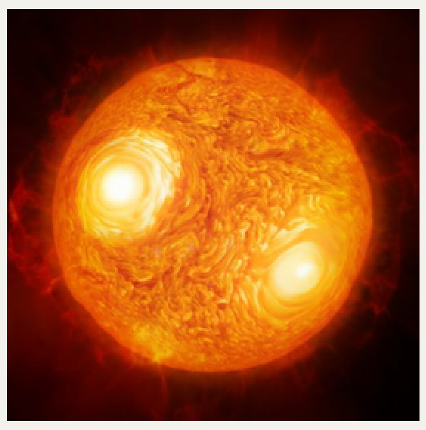
The emerging energy escapes through the stellar atmosphere, formed by:

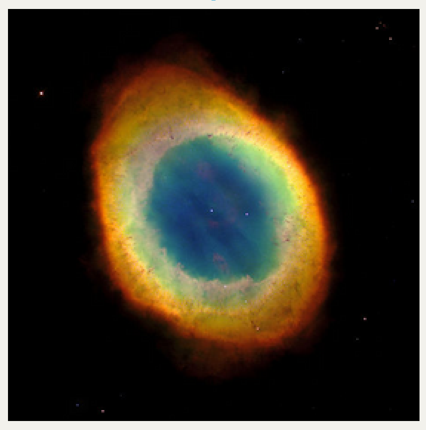
- Photosphere: Visible layer that emits light and allows spectral analysis of temperature, surface gravity and chemical composition.
- Chromosphere: Gaseous layer with temperatures ranging from 5,800 K to 20,000 K, influenced by the magnetic field and the dynamics of ionised particles.
- Corona: Outermost layer, consisting of ionised plasma and temperatures above 10^6 K, with very low density; observable during total solar eclipses.

Terminal stages

Planetary nebula and corresponding white dwarf

When helium fusion begins in the core, the triple-alpha process occurs, releasing energy in the form of gamma radiation. The energy generated is sufficient to expel the outer layers of the star, giving rise to the formation of a planetary nebula, a gaseous envelope composed mainly of helium, carbon and oxygen, with shapes that can be annular, spherical or irregular. The remaining core becomes a white dwarf, highly dense and hot. Although it has a radius comparable to that of Earth, its mass is close to that of the Sun, resulting in extremely high densities. At this stage, nuclear fusion does not occur; the emission of light and heat comes from the thermal residue accumulated during previous phases.





Red giant

When the hydrogen core is depleted in G-type stars, nuclear fusion in the centre ceases, breaking the hydrostatic equilibrium. Gravity causes the core to contract, raising its temperature until hydrogen fusion begins in a layer surrounding the inert helium core. This peripheral fusion generates sufficient pressure to expand the outer layers, transforming the star into a red giant. The surface cools to temperatures of approximately 3,000–4,000 K, while the luminosity increases significantly. During this phase, the star loses mass through stellar winds and exhibits convective pulsations that contribute to the expulsion of material into the surrounding space.

This poster presents the fundamental theoretical concepts regarding the evolution of G-type stars. The experimental aspects include obtaining astronomical photographs and processing the information obtained from them. Those interested in consulting the complete version of the theoretical framework and practical section can contact me using the details provided on this poster.