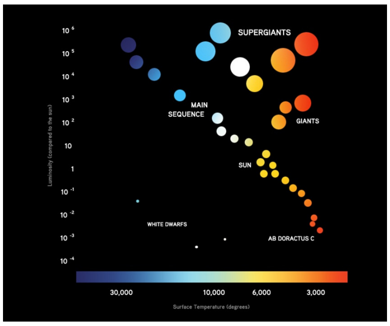
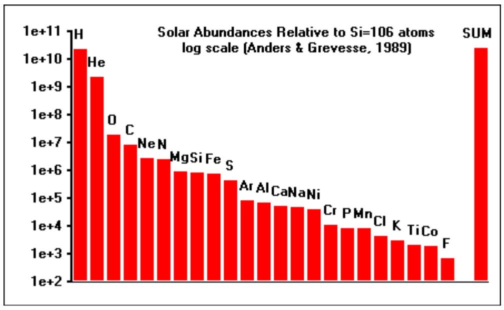
Sun series – Parts 11 – 20

Sun – Part 11 - Stellar spectral classification 2



Herzsprung-Russell diagram Cecilia Payne Gaposchkin S un element abundance

The fact that the Harvard system indicated a star's surface (photospheric) temperature was not fully understood until after its initial development. However, by 1914, when the Hertzsprung-Russell (H-R) diagram was formulated, this was generally suspected to be true, although it was only confirmed in the late 1920s. Because the sequence developed by Cannon predates understanding of it being a temperature sequence, placement of a spectrum into a given sub-type eg B3, A7, depends largely on subjective estimates of the strengths of absorption features in stellar spectra. As a result, these sub-types are not evenly divided into sort of mathematically representable intervals.

The H-R diagram is a graph on which a measure of the brightness of stars is plotted against a measure of their temperature. It shows how the luminosities and surface temperature of stars are linked. It was independently devised by the American astronomer Henry Norris Russell and the Danish astronomer Ejnar Hertzsprung. In 1905, Hertzsprung showed that a star's luminosity was related to spectral line width, a characteristic enabling calculation of its distance and, in 1906, plotted the first version of the H-R diagram. However, his work remained largely unknown, and, in 1910, Russell independently developed the diagram in a slightly different form. During this process, he found that red stars fall into two groups, giants and dwarfs. Unaware that Hertzsprung had done the same in 1906, in 1913, Russell further developed the diagram which, a year later, became known as Hertzsprung-Russell diagram. In 1928, Russell established the composition of the Sun's atmosphere from its spectrum.

The H-R diagram provides more than just information about a star's temperature and luminosity. From its position on the diagram, it is also possible to estimate its mass and stage of evolution. Most stars, including the Sun, lie in the main sequence ie they shine by converting hydrogen to helium in their core. The main-sequence is the diagonal strip on the diagram which runs from the top left to the bottom right. A star's position on this strip depends on its mass, with the most massive at upper left and the least massive at the lower right. Other areas on the diagram are populated by stars not burning hydrogen in their core, but which may be burning it in a thin surrounding shell. The giant branch is the most prominent of these areas, consistimg of stars which have exhausted the hydrogen fuel in their cores. Other features are the supergiants (luminosities 300-100,000 times that of the Sun) and white dwarfs (dying stars with luminosities typically 10,000 times the Sun).

The Sun, an average star, lies about half-way along the main-sequence. Whatever its mass, a star on the main-sequence is termed 'dwarf' and belongs to luminosity class V. Most stars are of this type, their masses ranging from 0.1-100 solar masses. The term 'dwarf' is used because stars in the main-sequence are smaller than those of the same mass which have evolved into giants. However, so-called white, black and brown dwarfs are not dwarfs in the sense of being main-sequence stars. Stars spend most of their lives on the main-sequence, remaining at roughly constant temperature and luminosity. The time they spend on main-sequence depends on their mass. For very massive stars, it lasts only a few million years, for least massive, potentially longer than the age of the Universe.

In the late 1920's, Russell suggested that all stars contain a high prop of hydrogen. However unknown to most, the same conclusion had originally reached, in 1925, by Cecilia Payne Gaposchkin, another of Pickering's computers. During work she undertook during the previous two years, she demonstrated that the O-M spectral sequence in the Harvard classification is actually a sequence of temperatures. The temperature scale she developed for the various types of stars based on the strengths of their spectral lines enabled her to accurately relate spectral classes to actual stellar temperatures. She showed that the great variation in stellar absorption lines was a consequence of differing amounts of ionisation at different temperatures, not to differing amounts of elements, as was currently assumed. Her findings allowed her to correctly conclude that silicon, carbon and common metals seen in the Sun's spectrum existed in about the same amounts as on Earth, but that hydrogen and helium were vastly more abundant in stars. Her research established that hydrogen is, by, far the largest constituent of stars. However, her findings were only published some time later.

Over time, the details of existing classes in the M-K system have been refined and additional classes have been added following newly discovered types of stars, but the system of stellar classification which has evolved since the 1860s has proved to be a sound one. It also has a role in the search for exoplanets, particularly those which may be habitable. The range of stars predicted to be able to support life is limited by several factors. In the main-sequence, stars more massive than 1.5 times that of the Sun ie types O, B or A age too quickly for advanced life to develop.
Dwarfs of less than half the Sun's mass (class M) are likely to tidally lock planets within their habitable zone, reducing the likelihood that life can develop.

Sources – Wikipedia, Dictionary, www.missionscience.nasa.org