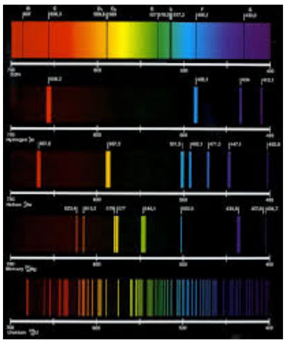
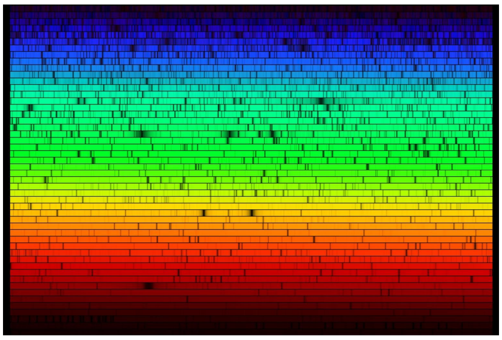
Sun – Part 10 - Stellar spectral classification 1


Sun's emission spectrum


Sun's absorption spectrum

The Sun is a G2V main-sequence star, or G dwarf star or, less accurately, yellow dwarf. It produces more yellow light than any other colour because of its surface temp of around 5.500 K. The hotter an object, the more the energy it radiates and the 'hotter' its colour. Thus, the colour of a star provides information about its temperature. These colours, and other characteristics, including luminosity (brightness), mass and distance can be identified from their spectra. This property, which has enabled scientists to classify stars according their spectral characteristics, has also provided valuable information on the nature and life cycle of stars.

Each line in a stellar spectrum indicates an ion of a certain chemical element. The line's strength indicates the abundance of that ion and the relative abundance of different ions varies with the temperature and density of its photosphere. Thus, the spectral class of a star, like the Sun, is a short code summarising its surface features.

Most stars are currently classified under the Morgan-Keenan (KN) or Yerkes system which was published in 1943. This two-dimensional system uses the letters O, B, A, F, G, K and M, a sequence from the hottest (O) to the coolest (M) type. These classes (and temperatures) relate to the optical colours of stars. The brightest (hottest) stars are white or blue-white, less hot ones yellow or orange, and cooler ones orange-red or red.

Each letter is then subdivided with a numeric digit, with 0 being the hottest and 9 the coolest eg A8, A9, F0, F1 or G2 like the Sun. Fractional numbers are allowed eg 0.97. The sequence has been expanded with classes for other stars and star-like objects that do not fit the classical system eg D for white dwarfs, C for carbon stars.

The second dimension of the M-K system was the addition of a luminosity class. Using Roman numerals, it is based on the width of certain absorption lines in the star’s spectrum which vary with density of the atmosphere, and so distinguish giant stars from dwarfs. In addition, stars have a luminosity class depending on their brightness. They are: class O or Ia+ for hypergiants, class Ia and Ib for supergiants, class II for bright giants, class III for regular gianst, class IV for sub-giants, class V for dwarfs (main-sequence stars eg Sun) class *sd* for sub-dwarfs and class D for white dwarfs. Thus, the Sun's full spectral classification of G2V identifies it as a yellow main-sequence star with a surface temperature around 5,000 K.

The M-K system is an advance on the earlier Harvard spectral classification, with more precise observational definition of each type and the addition of the numeric luminosity classification. The Harvard classification was also based on earlier systems. The reason for the odd letter arrangement in the Harvard system is historical, having evolved from earlier Secchi classes and being progressively modified as understanding improved. In 1866, Angelo Secchi, the pioneering Italian stellar spectroscopist created three classes in order to classify observed spectra. Class I included white and blue stars with broad, heavy hydrogen lines. This includes the modern class A and early class F types eg Vega, Altair. Class II contained yellow stars with less strong hydrogen, but more evident metallic lines eg Sun, Arcturus, Capella. This includes modern G and K as well as late class F types. Class III included orange to red stars with complex band spectra eg Betelgeuse, Antares. This corresponds to modern class M.

During the late 1890s, the Secchi system began to be superseded by what had became the Harvard classification. During the 1880s, the American astronomer Edward Pickering organised a survey of stellar spectra at Harvard Observatory using the objective prism method. The first product of this work was the 1890 Draper Catalogue of Stellar Spectra. Most of the spectra in this catalogue were classified by Williamina Fleming, one of several pioneering female 'computers' employed by Pickering to undertake the demanding, but repetitive work of analysing spectra and photographs. The Draper catalogue used a scheme in which the existing Secchi classes were divided into more specific classes, given letters A to N . Also, the letters O, P, and Q were used to describe unusual stars and features.

The Harvard classification evolved from the Draper classification. Also a one-dimensional system based on temperature only, it similarly used single letters of the alphabet, but with changes in letter order, and the addition of with numeric sub-divisions to group stars according to their spectral characteristics, specifically the temperature of a star's surface. O, B and A stars are sometimes called 'early type' and K and M stars 'late type'. This stems from an early 20th century model of stellar evolution in which stars started their lives as very hot early types and then gradually cool down into late type. This mechanism was proved incorrect following discovery that stars are powered by nuclear fusion, but the labels lived on.

In 1897, another Harvard computer, Antonia Maury placed a sub-type of Secchi's Class I ahead of the remainder of Class I, thus placing modern type B ahead of A. She was first to do this, although she did not use lettered spectral types, rather a series of 22 types numbered from I to XXII. It was Annie Jump Cannon who, in 1901, returned to using Draper lettered types, but dropped all except letters O, B, A, F, G, K and M, used in that order. She also retained P for planetary nebulae and Q for some peculiar spectra
She also used labels like B5A for stars halfway between types B and A, F2G for stars 1/5 of the way from F to G etc. By 1912, she had changed types B, A, B5A, F2G etc to B0, A0, B5, F2 etc, thus essentially establishing the modern Harvard classification system.

Sources – Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed rev,
www.en.wikipedia.org, www.missionscience.nasa.org