THE HERTZSPRUNG-RUSSELL DIAGRAM

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1. Introduction

Around 1900 it was becoming clear to astrophysicists that stars differ not only with respect to atmospheric temperature but also, for one and the same atmospheric temperature, with respect to luminosity, in other words, that two parameters are necessary to characterize a star.

In 1911 and the following years E. Hertzsprung and H. N. Russell, basing their researches on observational material pertaining to spectral types, colors and luminosities of stars, discussed the distribution of stars in color-luminosity, or color-spectral class diagrams, and described the most essential features of the distribution. A diagram in which stars are represented by points according to their spectral class and luminosity, or their color index and luminosity, is generally referred to as a Hertzsprung-Russell diagram (H-R diagram).

The relation between spectral class and effective temperature is now fairly well established. It depends to a certain degree on the luminosity. The same is true with respect to the relation between color index (which measures the intensity ratio between two suitably chosen wave-length regions) and effective temperature. Thus to each point in an H-R diagram (abscissa, spectral type or color index; ordinate, luminosity) we can assign an effective temperature. Since the effective temperature T_e determines the flux of energy F per unit area of the surface of the star, the latter quantity is a known function of position in the H-R diagram.

The luminosity L, which gives the total energy radiation per second, is usually measured by the absolute bolometric magnitude $M_{\text{bol}} = \text{constant} - 2.5 \log_{10} L$. The photometric observations yield quantities such as the visual magnitude and the photographic magnitude which measure the light intensity in wave-length regions around 5600 A and 4300 A, respectively, while the bolometric magnitude by definition measures the total energy of the spectrum. However, the reductions of visual or photographic magnitudes to bolometric magnitudes, the so-called bolometric corrections, are known as functions of the spectral class. Hence a visual or photographic absolute magnitude-color index diagram can easily be converted into a bolometric absolute magnitude-effective temperature diagram.

The luminosity of a star is equal to the surface times the flux F,

$$L = 4\pi R^2 F \tag{1}$$

where R is the radius of the star. Hence the radius can be computed from the luminosity and the effective temperature. In fact, since by the definition of the effective temperature T_e the flux F is proportional to T_e^4, we have

$$\frac{L}{L_\odot} = \left(\frac{T_e}{T_\odot}\right)^4 \left(\frac{R}{R_\odot}\right)^2 \tag{2}$$