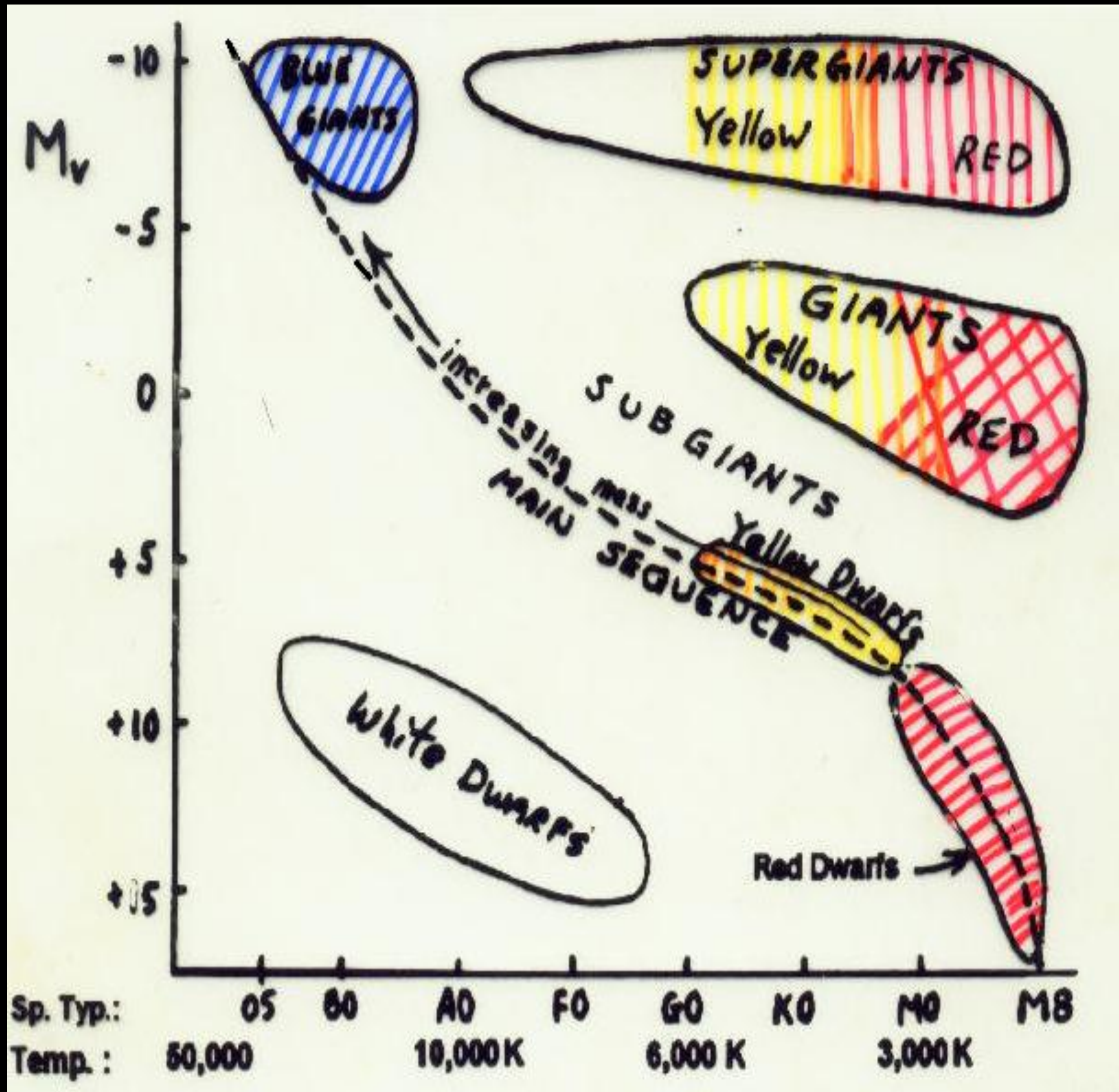
The Hertzsprung-Russell Diagram

In 1905, Ejnar Hertzsprung in Denmark compiled parallax and spectral class data for hundreds of stars.

He then computed the absolute magnitudes for these stars and published a paper wherein this data was presented in the form of a "Spectral-Luminosity Diagram."

This paper went unnoticed until 1913, when Henry Norris Russell of Princeton University did somewhat the same thing.

Russell also introduced terminology associated with the various groupings that the stars formed in the diagram.



BLUE GIANTS
SUPERGIANTS
Yellow
RED
GIANTS
Yellow
RED
SUBGIANTS
increasing mass
MAIN SEQUENCE
Yellow Dwarfs
White Dwarfs
Red Dwarfs
M_v
-10
-5
0
+5
+10
+15
Sp. Typ.:
O5
B0
A0
F0
G0
K0
M0
M8
Temp. :
50,000
10,000 K
6,000 K
3,000 K

The H-R Diagram

To plot a star as a point in the H-R diagram, one must measure the parallax of the star to calculate the star's distance. Only then, can the absolute magnitude, M, of the star be found.
This can be done for about 2,000 stars.

The different groupings of stars in the H-R diagram represent long-lived stages of evolution. Statistically, one expects to find a larger number of stars in the longer-lived stages of evolution.

The main sequence of stars represents a relatively long-lived stage of stellar evolution, therefore one finds that most stars fall along this locus.

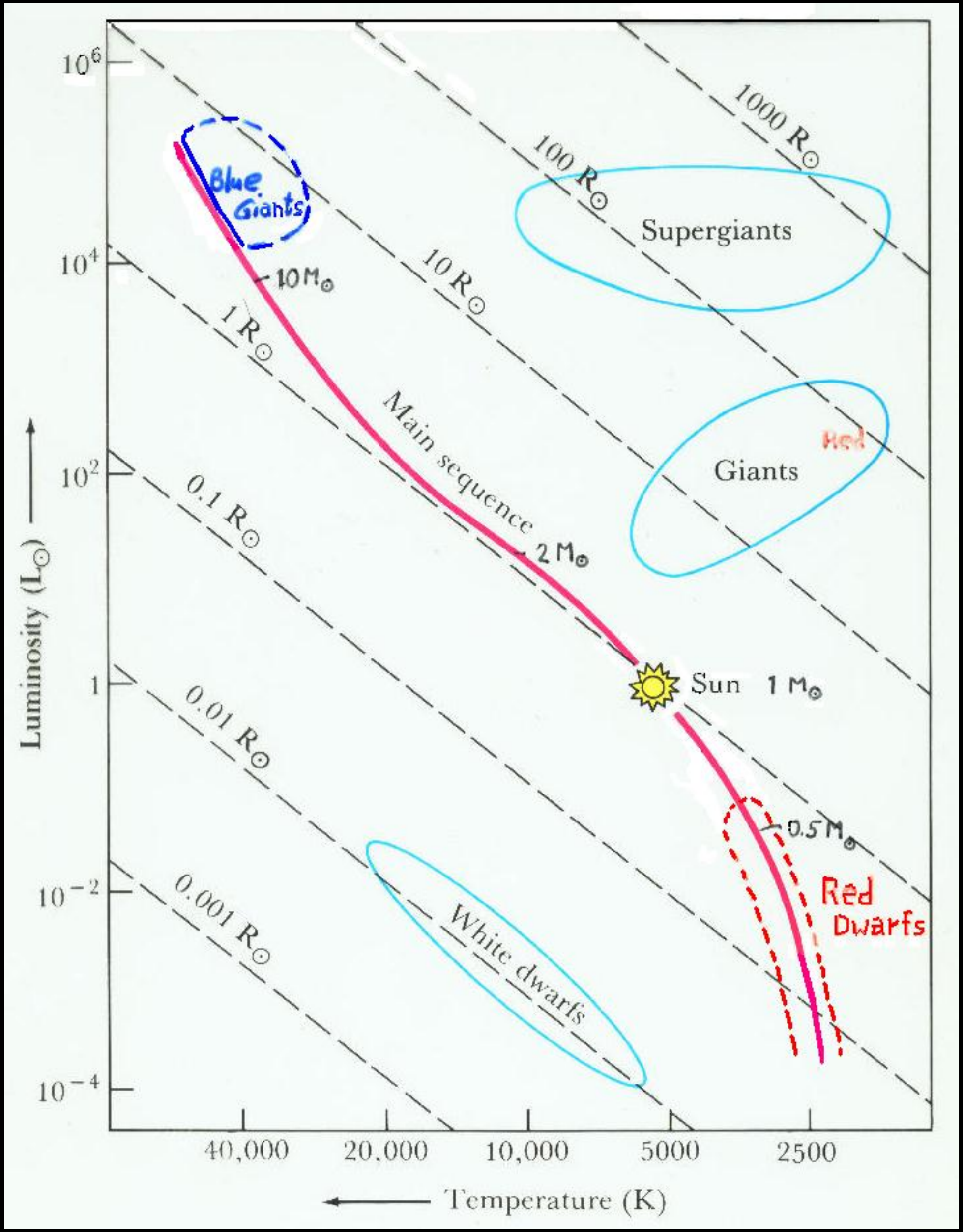
Stars on the main sequence are delineated by mass, which is expressed as the Mass-Luminosity Law: The greater the mass of a main sequence star, the brighter it is.

Determining Stellar Sizes

Three Methods:

1. $L_* = 4\pi R^2(\sigma T^4)$ if M and T are found.
2. Interferometry. Most direct method.
3. Analyzing the light curve of an eclipsing binary star system.

Hertzsprung-Russell Diagram Showing Loci of Constant Radii



Determining Stellar Masses

The mass of a star can only be determined if the star interacts with another object. This happens in a binary star system. This has led to the:

Mass Luminosity Law for Main Sequence Stars.

Range of stellar Masses: .06 to 110 $M_{\odot}$.

The upper limit on mass is set by radiation pressure. More massive stars would not be stable and would blow apart.

Kumar Limit: Smallest mass needed to initiate TNF in a developing star. This is the lower limit above. Objects with a mass less than the Kumar limit become objects similar to Jupiter but larger. They are called **Brown Dwarfs**

LUMINOSITY CLASSES

Designated by: I, II, III, IV, V, VII.

This assignment is made by studying the widths of the spectral lines.

The widths of a star's spectral lines depend on the pressure in the star's atmosphere and how fast the star rotates.

In general, the larger the star the lower the gas pressure in its atmosphere and the narrower its spectral lines.

Also, the slower a star rotates, the narrower its spectral lines. Therefore, the determination of the luminosity class is a complex problem.

I designates a supergiant. This class is subdivided into 1a and 1b.

II designates a bright giant.

III stands for a giant star

IV indicates a subgiant.

V means a main sequence star.

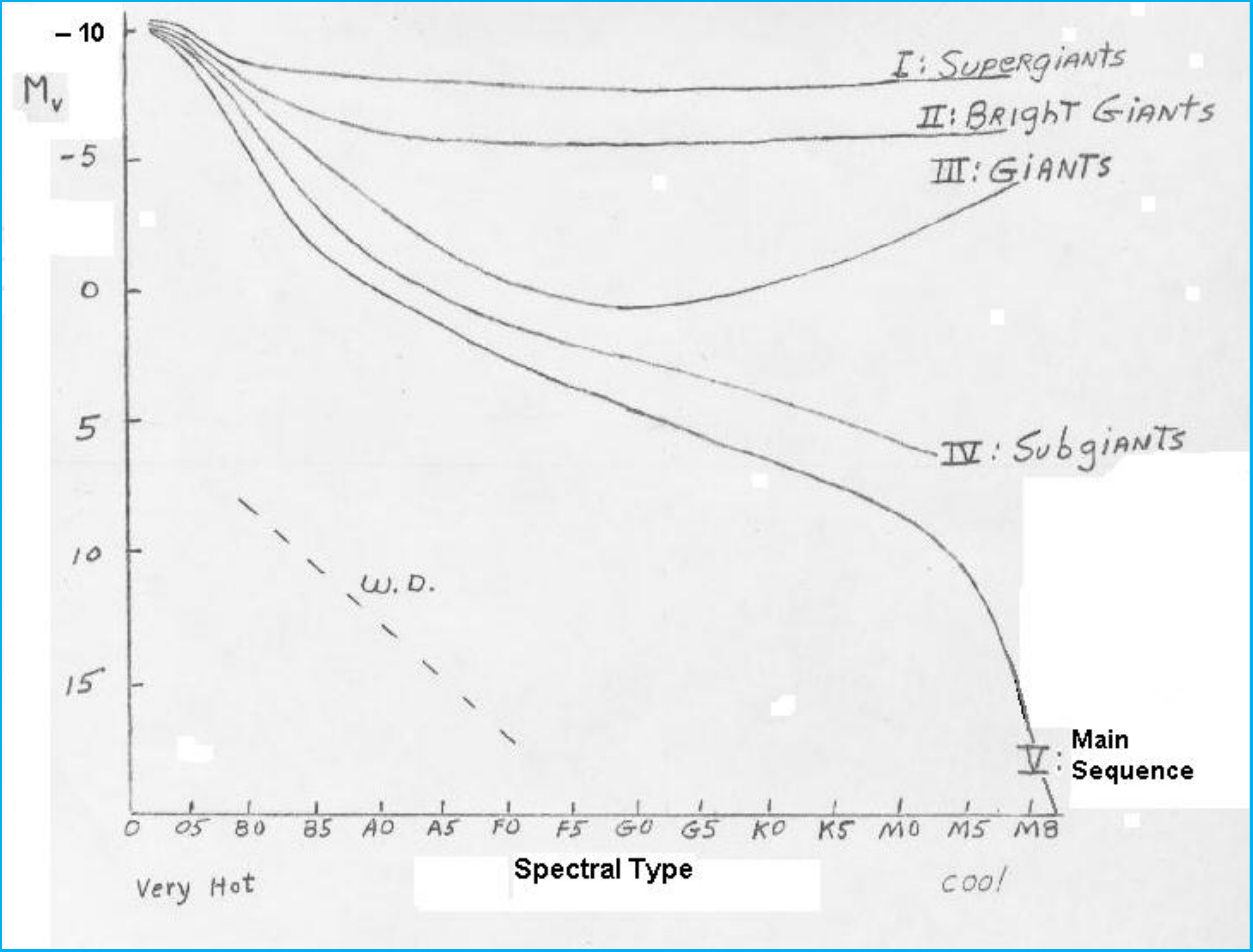
VII indicates a white dwarf.

Spectral Types and Luminosity Classes are usually quoted together. Examples:

The Sun is classified as a G2 V star.

K5 III would be a relatively cool giant star.

S-L Diagram with Luminosity Classes



Spectroscopic Parallax

This is a technique for determining the distance of a star that if it is beyond the range for measuring parallax (100 pc).

It makes use of the H-R diagram to find the absolute magnitude of a star for which the spectral type and luminosity class have gleaned from the spectrum.

Once the absolute magnitude is known, the distance of the star may be calculated using

$$M = m + 5 - 5Log(HD).$$