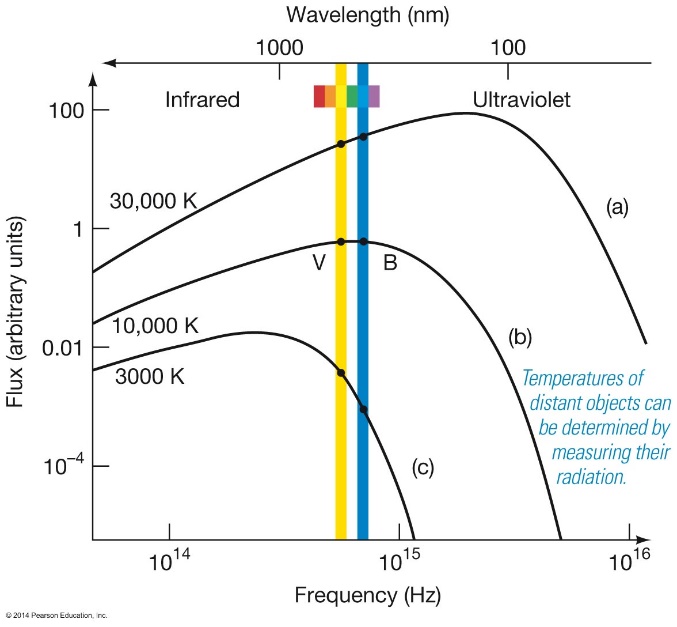
**HR Diagram**

**Purpose:** To make your own Hertzsprung-Russell (HR) diagrams and learn what the various points represent.

**Introduction:**

Plotting the temperature of a star, or its color index, against its absolute magnitude shows a definite pattern. Main sequence stars will lie in a well defined region that looks similar to a diagonal, stretched ‘s’. Stars have left the main sequence all slide to the upper right. Astronomers have developed several clever ways to find stellar luminosities and temperatures from quantities that we can directly observe. The most difficult part of making an H-R diagram is finding the luminosities of stars. Since we can't go to stars, all we can know about them is what we can see from Earth.

Astronomers have several ways to find the temperatures of stars, but the simplest way is to look at the stars' colors. In astronomy, a star's color is defined as the difference between its magnitudes as seen through two different filters. Traditionally, astronomers have taken images through blue, yellow, and red filters denoted by the letters b, v, and r. If you subtract a star's v magnitude from its b magnitude, you get a color called b-v. Stars with lower b-v colors have higher temperatures, so you can use b-v color to make an H-R diagram.

**Procedure:**

**Part I: HR Diagram for the brightest stars in the sky**

The first H-R diagram you should try is a diagram for the brightest stars in the sky. The table below shows the 26 brightest stars in the sky. Instead of plotting their luminosities (which are so large that they're hard to visualize), plot the stars' absolute magnitudes with brighter stars going toward the top. Since brighter stars have lower magnitudes, if you choose to plot magnitude on the y-axis, the values will decrease as you go up! Plot temperature on the x-axis. However, since we can't know a star's real temperature, you should instead plot color (b-v) on the x-axis. Traditionally, hotter stars have been placed at the left of the chart and cooler stars to the right. Even though the temperature decreases as you move the right, the b-v values will increase. So you should make your H-R diagram with b-v increasing to the right

|  |  |  |  |
| --- | --- | --- | --- |
| **Star Name** | **Apparent Magnitude** | **Absolute Magnitude** | **b-v** |
| Sun | -26.8 | 4.8 | 0.63 |
| Sirius | -1.46 | 1.4 | 0 |
| Canopus | -0.72 | -2.5 | 0.15 |
| Arcturus | -0.04 | 0.2 | 1.23 |
| Alpha Centauri | -0.01 | 4.4 | 0.71 |
| Vega | 0 | 0.6 | 0 |
| Capella | 0.08 | 0.4 | 0.08 |
| Rigel | 0.12 | -8.1 | -0.03 |
| Procyon | 0.38 | 2.6 | 0.42 |
| Betelgeuse | 0.41 | -7.2 | 1.85 |
| Achernar | 0.46 | -1.3 | -0.16 |
| Hadar | 0.63 | -4.4 | -0.23 |
| Acrux | 0.76 | -4.6 | -0.24 |
| Altair | 0.77 | 2.3 | 0.22 |
| Aldebaran | 0.85 | -0.3 | 1.54 |
| Antares | 0.92 | -5.2 | 1.83 |
| Spica | 1 | -3.2 | -0.23 |
| Pollux | 1.14 | 0.7 | 1 |
| Formalhaut | 1.16 | 2 | 0.09 |
| Becrux | 1.2 | -4.7 | -0.23 |
| Deneb | 1.25 | -7.2 | 0.09 |
| Regulus | 1.35 | -0.3 | -0.11 |
| Adhara | 1.5 | -4.8 | -0.21 |
| Shaula | 1.6 | -3.5 | -0.22 |
| Gacrux | 1.63 | -1.2 | 1.59 |
| Castor | 1.98 | 0.5 | 0.03 |

1. Make an H-R diagram for the brightest stars by graphing b-v and absolute magnitude for the 26 stars above. Copy data in the table to Excel, select scatter chart to plot absolute magnitude on the y-axis and b-v on the x-axis. After you finish plotting, select y axis, right click, select format axis and check the box in front of “ Values in reverse order”. Label both x and y axis. Copy and paste the plot blow. Keep in mind that from the origin, absolute magnitude will decrease as you go up and the b-v starts negative becomes larger to the right.
2. The stars in the upper right of the diagram are very bright but are also very cool. If the stars are cool, why do you think they are so bright?
3. Where does our sun plot on this diagram? Is it hotter or cooler than average? Does it emit more or less light than average?

**Part II: HR Diagram for the nearest stars**

In this exercise, you will make a slightly different type of H-R diagram. Instead of graphing absolute magnitude vs. b-v color, you will graph absolute magnitude vs. spectral type. Looking at a star's spectral type - defined by the peaks and valleys in its spectrum - is an another way of finding the star's temperature.

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| spectral types classification, O (0-9), B (10-19), A (20-29), F (30-39), G (40-49), K (50-59), and M (60-69) |

To use the spectral types classification in Excel, you will need to convert the spectral type's letter-number designation into a number. The temperature order of spectral types, from hottest to coolest, is OBAFGKM. There are also spectral subtypes 0 - 9 for each type. Let spectral type O be the digits 0 - 9, B be 10 - 19, A be 20 - 29, and so on. For example, if you had a G2 star (like our Sun) you would enter spectral digits of 42.

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| --- | --- | --- | --- | --- | --- |
| **Star Name** | **Distance (light years)** | **Apparent Magnitude** | **Absolute Magnitude** | **Spectral Type** | **Spectral digits** |
| Sun | 0 | -26.8 | 4.8 | G2 |  |
| Proxima Centauri | 4.2 | 11.05 | 15.5 | M5.5 |  |
| Alpha Centauri A | 4.3 | -0.01 | 4.4 | G2 |  |
| Alpha Centauri B | 4.3 | 1.33 | 5.7 | K1 |  |
| Barnard’s Star | 6.0 | 9.54 | 13.2 | M3.8 |  |
| Wolf 359 | 7.7 | 13.53 | 16.7 | M5.8 |  |
| BD +36 2147 | 8.2 | 7.5 | 10.5 | M2.1 |  |
| Luyten 726-8A | 8.4 | 12.52 | 15.5 | M5.6 |  |
| Luyten 726-8B | 8.4 | 13.02 | 16 | M5.6 |  |
| Sirius A | 8.6 | -1.46 | 1.4 | A1 |  |
| Ross 154 | 9.4 | 10.45 | 13.1 | M3.6 |  |
| Ross 248 | 10.4 | 12.29 | 14.8 | M4.9 |  |
| Epsilon Eri | 10.8 | 3.73 | 6.1 | K2 |  |
| Ross 128 | 10.9 | 11.10 | 13.5 | M4.1 |  |
| 61 Cyg A | 11.1 | 5.2 | 7.6 | K3.5 |  |
| 61 Cyb B | 11.1 | 6.03 | 8.4 | K4.7 |  |
| Epsilon Ind | 11.2 | 4.68 | 7.0 | K3 |  |
| BD +43 44 A | 11.2 | 8.08 | 10.4 | M1.3 |  |
| BD +43 44 B | 11.2 | 11.06 | 13.4 | M3.8 |  |
| Procyon A | 11.4 | 0.38 | 2.6 | F5 |  |
| BD +59 1915 A | 11.6 | 8.90 | 11.2 | M3.0 |  |
| BD +59 1915 B | 11.6 | 9.69 | 11.9 | M3.5 |  |
| CoD -36 15693 | 11.7 | 7.35 | 9.6 | M1.3 |  |

1. Find the spectral digits for stars according to their spectral type, and record the value in the table.
2. Make an H-R diagram for the closest stars. Copy data in the table to Excel, select scatter chart to plot absolute magnitude on the y-axis and spectral digits on the x-axis. After you finish plotting, Select y axis, right click, select format axis and check the box in front of “Values in reverse order”. Label both x and y axis. Copy and paste the plot blow. Keep in mind that from the origin, absolute magnitude will decrease as you go up and the spectral digits becomes larger to the right.
3. How does this diagram differ from the diagram for the brightest stars?
4. How does our Sun compare to the other stars in our neighborhood?