Two stages of calculations

Stage 1: Estimate the host star’s absolute luminosity based on the star’s apparent visual magnitude (three steps)

First Step – Calculate the absolute visual magnitude of the host star based on the star’s apparent magnitude.

\[ M_v = m_v - 5 \log(d/10) \]

Where:

- \( M_v \) = Absolute magnitude of the star
- \( m_v \) = apparent magnitude of the star (visual spectrum)
- \( d \) = distance from Earth to the star in parsecs

Second Step – Calculate bolometric magnitude of the host star.

\[ M_{\text{bol}} = M_v + BC \]

Where:

- \( M_{\text{bol}} \) = bolometric magnitude of the star
- \( BC \) = bolometric correction constant

Use the following table for general bolometric correction values [generalized from Habets and Heintz (1981)]

<table>
<thead>
<tr>
<th>Spectral class</th>
<th>BC</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>-2.0</td>
</tr>
<tr>
<td>A</td>
<td>-0.3</td>
</tr>
<tr>
<td>F</td>
<td>-0.15</td>
</tr>
<tr>
<td>G</td>
<td>-0.4</td>
</tr>
<tr>
<td>K</td>
<td>-0.8</td>
</tr>
<tr>
<td>M</td>
<td>-2.0</td>
</tr>
</tbody>
</table>
Third Step – Calculate the absolute luminosity of the host star

\[ \frac{L_{\text{star}}}{L_{\text{sun}}} = 10^{\left[ \frac{M_{\text{bol\ star}} - M_{\text{bol\ sun}}}{-2.5} \right]} \]

Where:

\( \frac{L_{\text{star}}}{L_{\text{sun}}} \) = the absolute luminosity of the star in terms of the absolute luminosity of the sun

\( M_{\text{bol\ star}} \) = the bolometric magnitude of the host star

\( M_{\text{bol\ sun}} \) = the bolometric magnitude of the sun = 4.72

2.5 is a constant value used for comparing stellar luminosities -- known as "Pogson's Ratio."

Stage 2: Estimate the radii of the host star’s habitable zone boundaries

One step – Place the value for the host star’s absolute luminosity (that you calculated above) into the expressions below.

\[ r_i = \sqrt{\frac{L_{\text{star}}}{1.1}} \]

\[ r_o = \sqrt{\frac{L_{\text{star}}}{0.53}} \]

Where:

\( r_i \) = the inner boundary of the habitable zone in astronomical units (AU)

\( r_o \) = the outer boundary of the habitable zone in astronomical units (AU)

\( L_{\text{star}} \) is the absolute luminosity of the star
**Example**

Star Gl 581

\[ m_v = 10.55 \]

Spectral type = M3

Distance = 6.21 parsecs

Calculate absolute visual magnitude

\[ M_v = m_v - 5 \log (\text{Distance}/10) = 11.58 \]

Calculate bolometric magnitude

\[ M_{\text{bol}} = M_v + (-2.0) = 9.58 \]

Calculate absolute luminosity

\[ \frac{L_{\text{Gl 581}}}{L_{\odot}} = 10^{\left[ \frac{9.58 - 4.72}{-2.5} \right]} = 0.011 \]

Estimate the boundaries of the habitable zone for this star

\[ r_i = \sqrt{\frac{0.011}{1.1}} = 0.1 \text{ AU} \]

\[ r_o = \sqrt{\frac{0.011}{0.53}} = 0.14 \text{ AU} \]

**References**


