Hydrostatic Equilibrium
Spectral Lines

- Hydrogen
- Sodium
- Helium
- Neon
- Mercury
Electronic Energy Levels

- Absorption
- Emission
- Ionization

- Lyman series
- Balmer series
- Paschen series

- Ground state
Franhofer & Bunsen
Absorption Lines

- Continuum Spectrum
- Emission Line Spectrum
- Absorption Line Spectrum

- Hot Gas
- Cold Gas
Equivalent Width of Line

- Continuum intensity level
- Spectral line profile area, $A$
- Equivalent width $b$
Stellar Spectra

[Diagram of stellar spectra with various lines and labels for different wavelengths and elements like Hα, Hβ, MgII, FeII, Hγ, etc.]

Wavelength (Å)

4000  5000  6000  7000
Harvard Classification System

Annie Jump Cannon

Antonia Maury
<table>
<thead>
<tr>
<th>Spectral Class</th>
<th>Intrinsic Color</th>
<th>Surface Temperature (K)</th>
<th>Prominent Absorption Lines</th>
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<tbody>
<tr>
<td>O</td>
<td>Blue</td>
<td>41,000</td>
<td>He⁺, O⁺⁺, N⁺⁺, Si⁺⁺, He, H</td>
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<tr>
<td>B</td>
<td>Blue</td>
<td>31,000</td>
<td>He, H, O⁺, C⁺, N⁺, Si⁺</td>
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<tr>
<td>A</td>
<td>Blue-white</td>
<td>9,500</td>
<td>H(strongest), Ca⁺, Mg⁺, Fe⁺</td>
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<tr>
<td>F</td>
<td>White</td>
<td>7,240</td>
<td>H(weaker), Ca⁺, ionized metals</td>
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<tr>
<td>G</td>
<td>Yellow-white</td>
<td>5,920</td>
<td>H(weaker), Ca⁺, ionized &amp; neutral metal</td>
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<td>K</td>
<td>Orange</td>
<td>5,300</td>
<td>Ca⁺(strongest), neutral metals strong, H(weak)</td>
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<tr>
<td>M</td>
<td>Red</td>
<td>3,850</td>
<td>Strong neutral atoms, TiO</td>
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Variation of Spectral Lines

- Hydrogen
- Ionized helium
- Helium
- Ionized iron
- Ionized calcium
- Titanium oxide
Spectra of Dwarf Stars (Luminosity Class V)

- B0 hotter than B9
- O - F5 = “Early” Type
- F5 - T = “Late” Type
Zöllner’s (Incorrect) Hypothesis

Late-type

Early-type

Evolution

M K G F A B O
Hertzsprung-Russell Diagram
H-R Diagram

- hot, bright
- cool, bright
- hot, dim
- cool, dim

L (L_{sun}) vs. T (K)
Main Sequence Size

\[ L = 4\pi R^2 \sigma T^4 \]
Lines of Constant Radius
MKK Classification System

William W. Morgan  Philip Keenan  Edith Kellman
<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Relative flux + C</th>
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<td>Ia-0</td>
<td>Hypergiant</td>
<td>122 (B0.2IV)</td>
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<td>Ia</td>
<td>Bright supergiant</td>
<td>138 (B0.5V)</td>
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<td>Iab</td>
<td>Normal supergiant</td>
<td>010 (B1Ib)</td>
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<tr>
<td>Ib</td>
<td>Subluminous supergiant</td>
<td>244 (B1II)</td>
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<tr>
<td>II</td>
<td>Bright giants</td>
<td>065 (B1III)</td>
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<tr>
<td>III</td>
<td>Normal giants</td>
<td>094 (B1III)</td>
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<td>IV</td>
<td>Subgiant</td>
<td>110 (B1III)</td>
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<td>V</td>
<td>Main-sequence (dwarf) star</td>
<td>133 (B1III)</td>
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<td>175 (B1III)</td>
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<td>108 (B1V)</td>
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<td>112 (B2V)</td>
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Wavelength (Å)
Roman Numeral

Sun: G2V