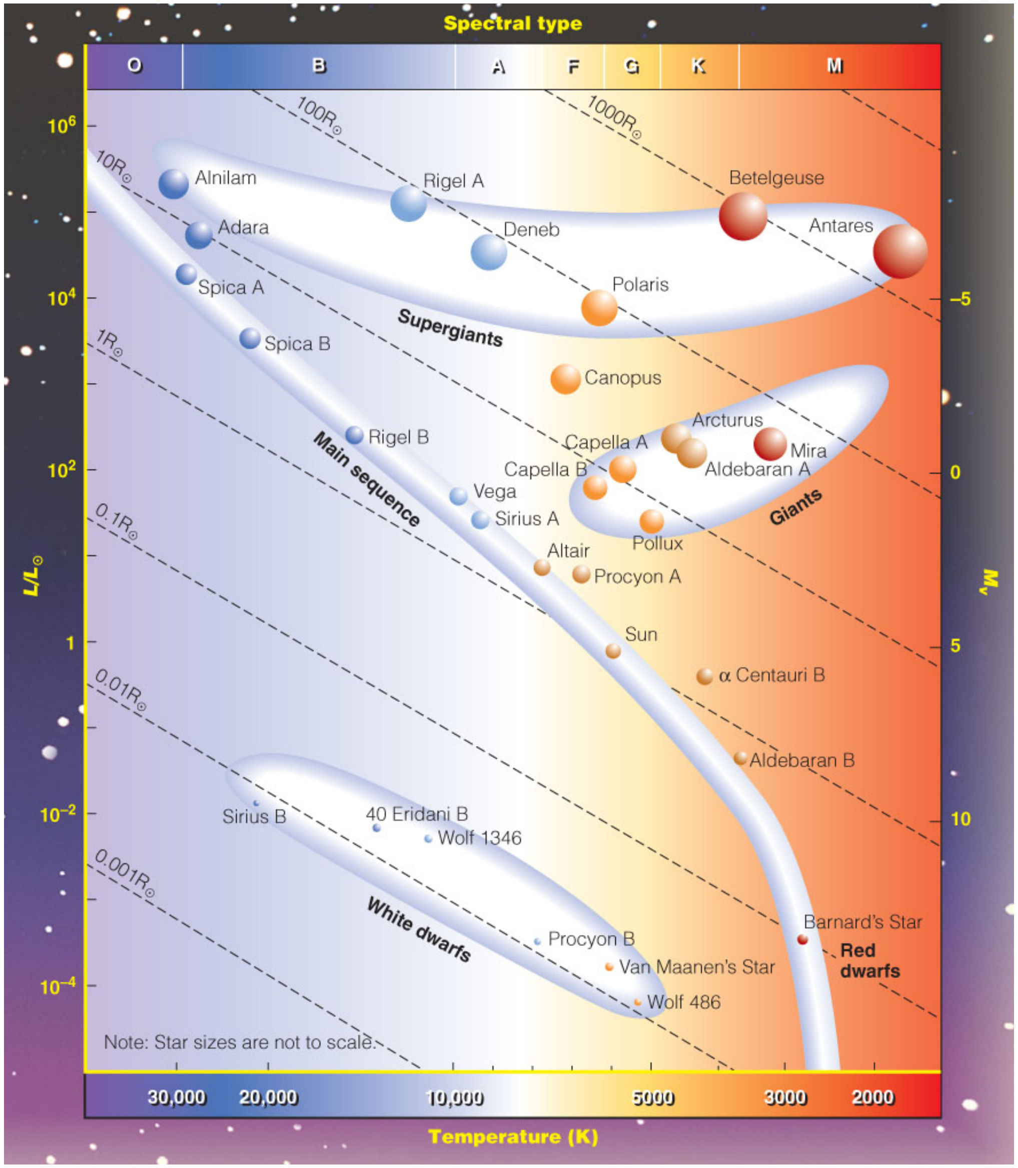
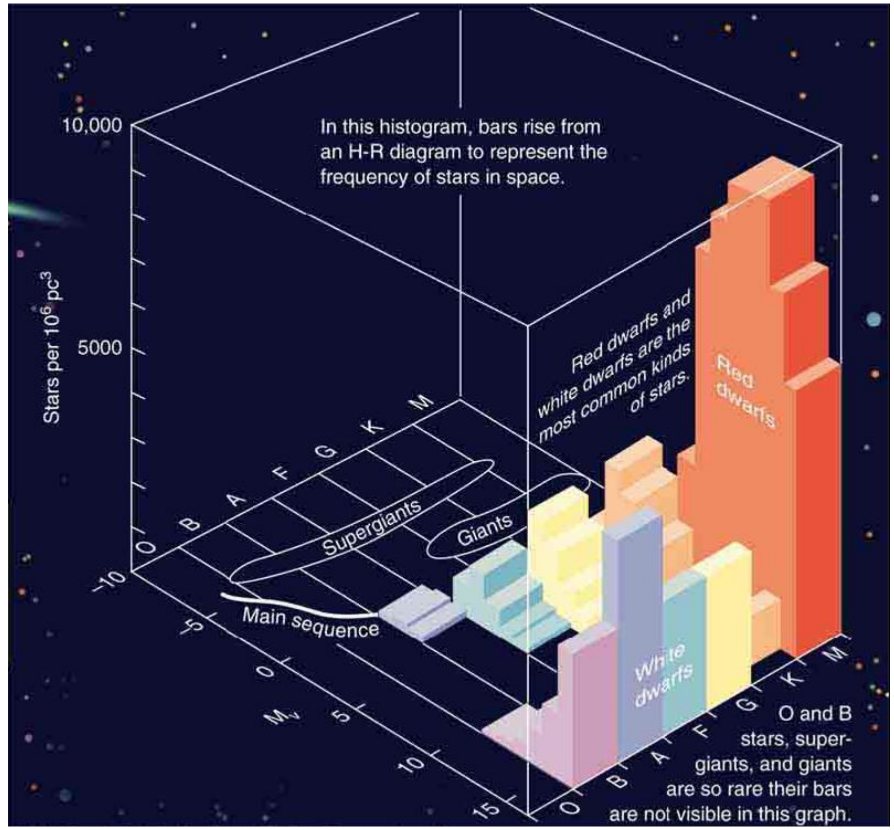
Stellar Structure

What have we learned?

- Can determine surface temperature via blackbody radiation, and absorption spectra
- Can determine relative magnitude, and after determining distance through parallax, absolute magnitude => Luminosity
- Relating black-body intensity to Luminosity yields surface and hence radius and volume

Hertzsprung-Russel Diagram





How do we find the mass?

- Use binary stars. Need a little relativity…

4-vector: Event $(ct, x, y, z) = (ct, \vec{r}) =: (x^0, x^1, x^2, x^3) = x^\mu, \mu = 0\ldots3$

For an inertial system S' moving along the x-axis of S with constant velocity $v < c$, and with all axes aligned and the same origin ($x^\mu = (0,0,0,0) \Leftrightarrow x'^\mu = (0,0,0,0)$):

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}; x' = \gamma\left(x - \frac{v}{c}ct\right); ct' = \gamma\left(ct - \frac{v}{c}x\right); y = y'; z = z'$$

Clocks in S' appear to S as if they were going slow by factor $1/\gamma$, and vice versa.

Length of object at rest in S' appears contracted by factor $1/\gamma$ in S.

Velocity addition: $$\frac{u_x}{c} = \frac{\frac{u_x'}{c} + \frac{v}{c}}{1 + \frac{u_x'}{c}\frac{v}{c}}; \frac{u_y}{c} = \frac{\frac{1}{\gamma}\frac{u_y'}{c}}{1 + \frac{u_x'}{c}\frac{v}{c}}.$$

Doppler shift: $\frac{\lambda_{obs}}{\lambda_{emitted}} = (z+1) = \frac{1 + v_{\parallel}/c}{\sqrt{1 - v^2/c^2}}$ (v is the **relative** velocity between emitter and observer and $v_{\parallel}$ is its component along the line of sight; $z > 0$ is redshift, $z < 0$ is blueshift)

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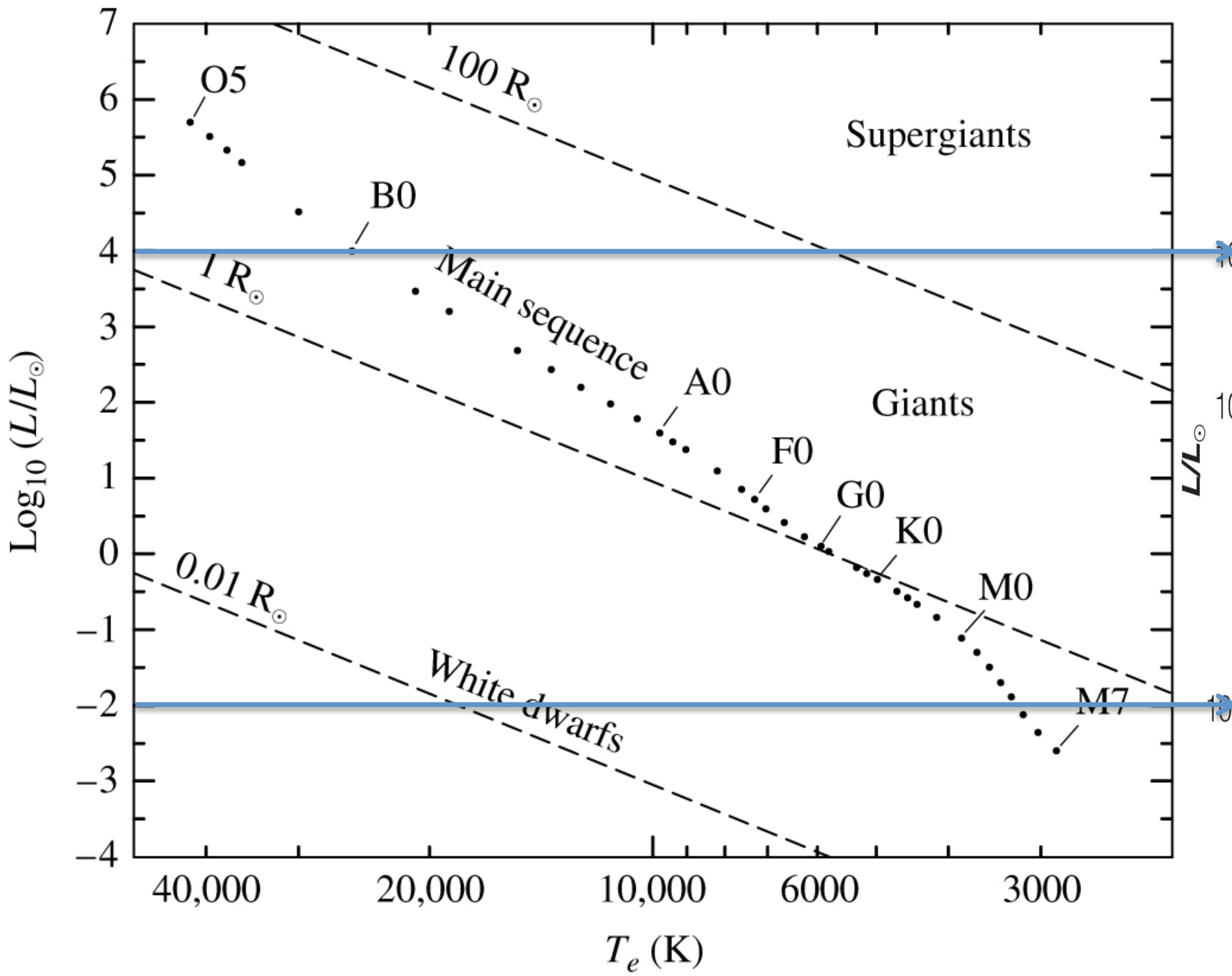
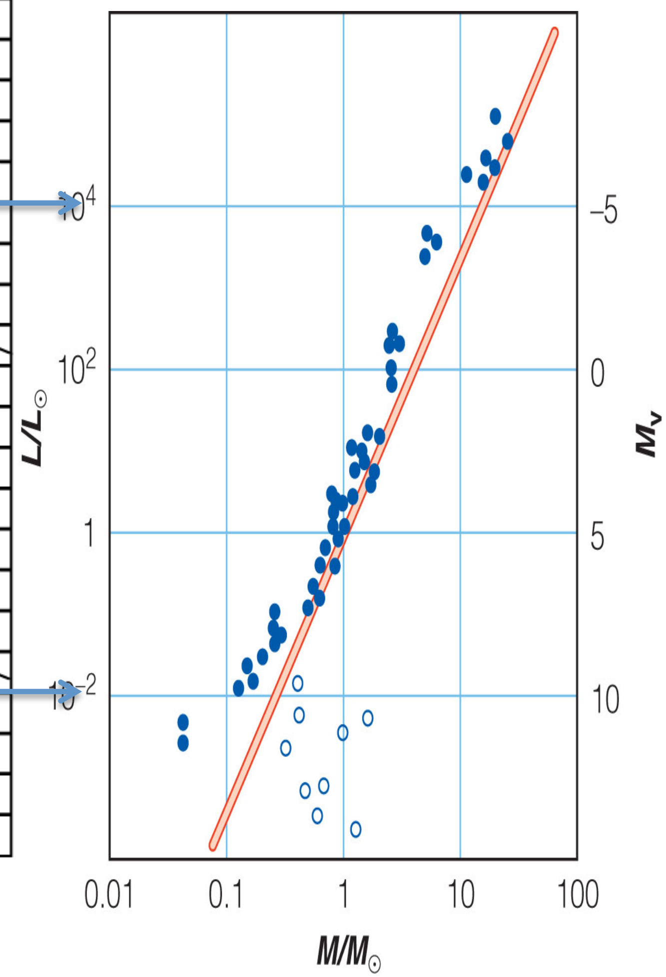
- Can determine relative magnitude, and after determining distance through parallax, absolute magnitude => Luminosity
- Relating black-body intensity to Luminosity yields surface and hence radius
- Binary stars: red- and blue shift of spectral lines determines absolute velocities; time dependence determines angular velocity of rotation around common center of gravity => distance of both stars from center of gravity
- Kepler's law gives sum of masses and Newton's 3rd law gives ratio of masses => individual masses
- Combining everything: average density

Hertzsprung-Russel Diagram





Question: How do we deduce interior structure of stars from these observations?