Stellar Lifetimes

- The Sun (and all stars) will eventually run out of fuel (hydrogen in regions where it is hot enough for fusion).
- If all the hydrogen in the Sun could fuse to helium, the Sun's lifetime would be 100 billion years.
- But, by the time about 10% of the Sun's H has been converted into He the solar structure will be changed and it will not be a main-sequence star.

Stellar Lifetimes

- The Sun has a main-sequence lifetime of 10 billion years. What about the other stars?

  (1) The <u>fuel</u> for stars is mass

  (2) The <u>fuel consumption rate</u> is Luminosity

  So, it's easy!

$$\boxed{Life_{m\square s} \quad \frac{Mass}{Luminosity}}$$

Example Stellar Lifetime

Suppose you have a $15M_o$ star with a luminosity of $L=10{,}000L_o$. How long will this star spend on the main sequence?

$$\boxed{Lifetime(15M_o) = \frac{15}{10000} \square Lifetime(1M_o)}$$

15 times as much fuel extends the life of the star

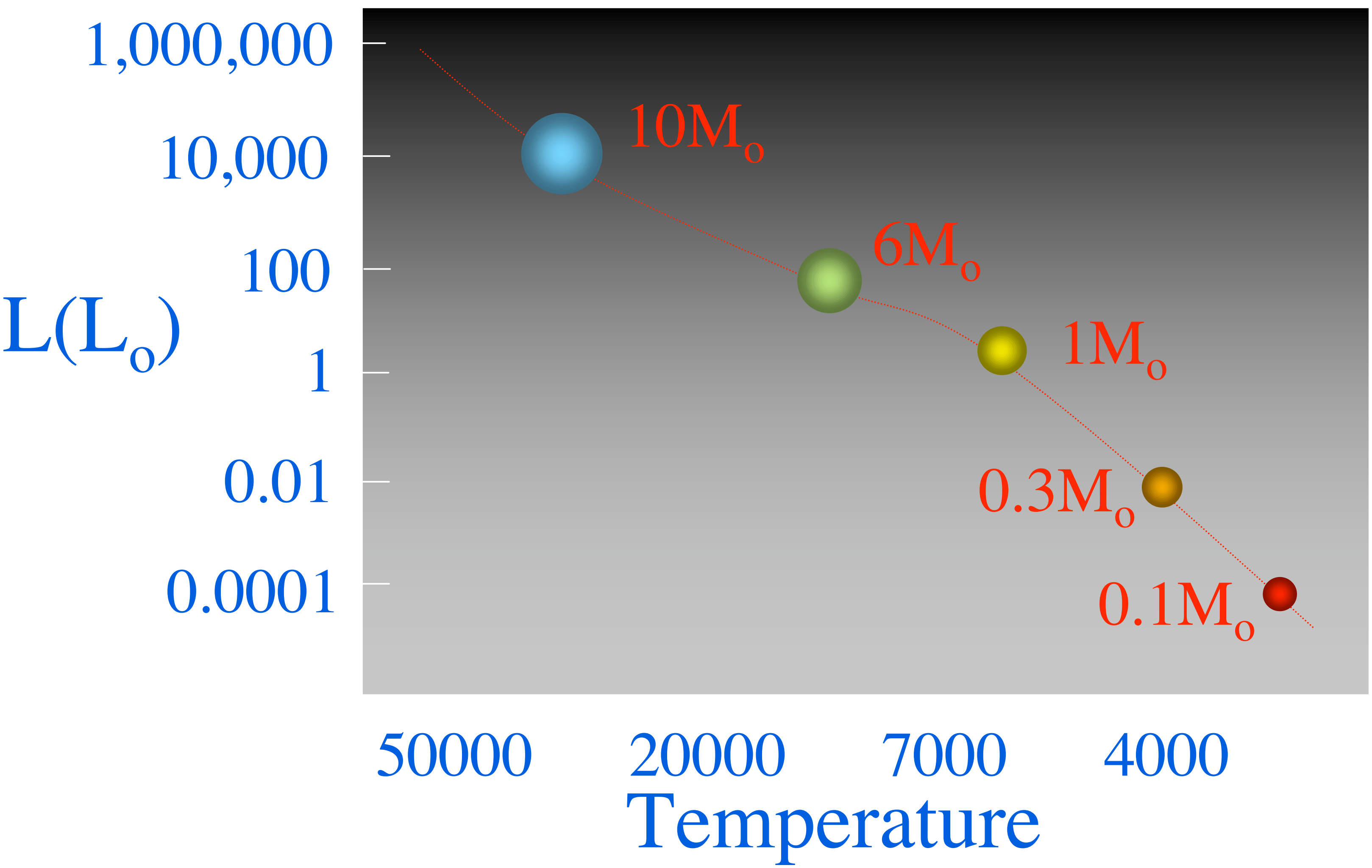
10,000 times L decreases the lifetime

Stellar Lifetimes

- So based on the extra fuel, you expect this star to live longer than the Sun, but this is more than counteracted by the high rate of using the fuel. This is the general trend.

Massive stars are like gas-guzzling SUVs
Low-mass stars are Toyota Prius.

Lifetimes can be read from a plot of Mass vs L



Stellar Lifetimes

- Remember there was a Mass-Luminosity relation for the main sequence. This gives the mass-lifetime relationship:

$$L \quad M^4$$

$$Lifetime \quad \frac{M}{L} = \frac{M}{M^4} = \frac{1}{M^3}$$

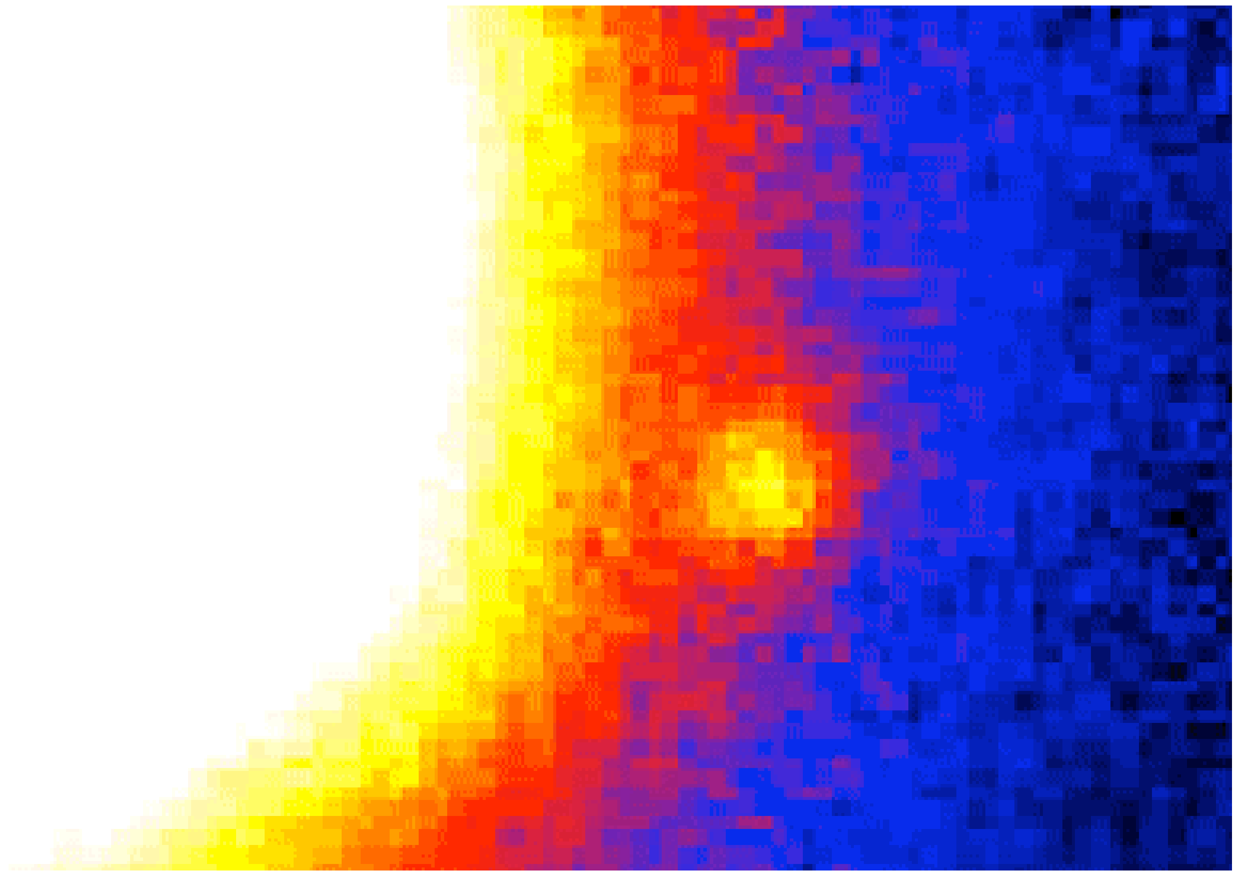
- Lifetimes range from a few million to 100 trillion years.

Lower Mass Limit for Stars

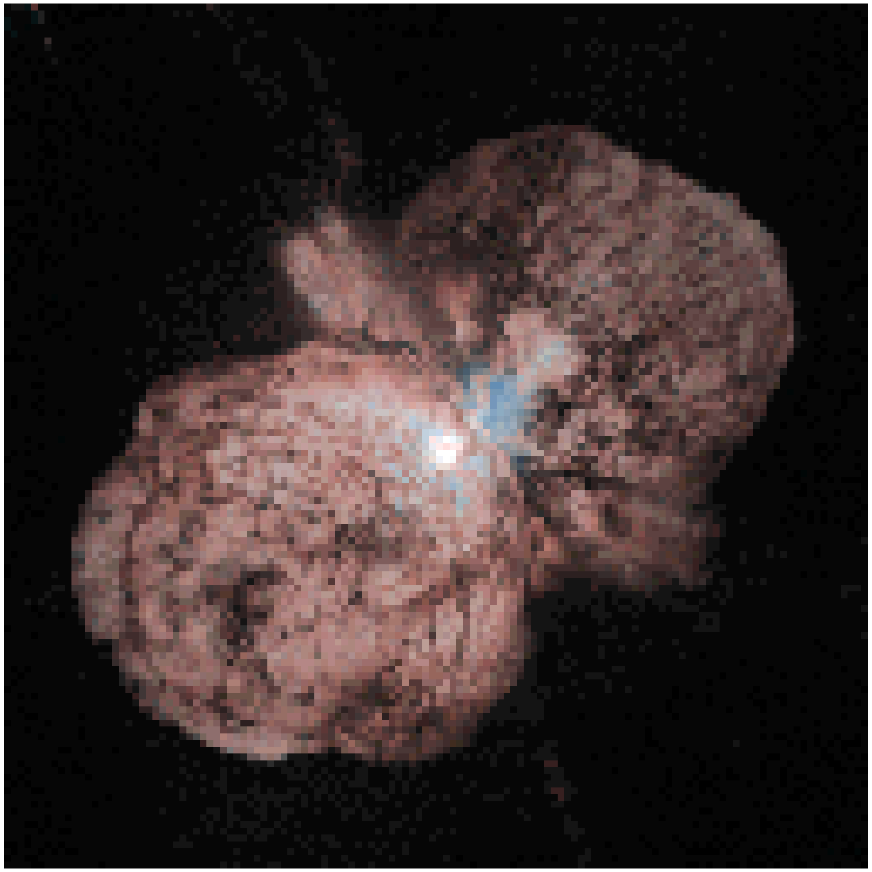
- We now can see why there is a lower limit for the mass of a star of about $0.08M_o$.
- For decreasing mass, the central temperature of a star decreases. At $0.08M_o$ the central temperature drops below 10 million k and it is too cool for P-P fusion!

- We call these objects `Brown Dwarfs'

GL229B (1995)



Upper Stellar Mass Limit



Eta Carina is a star of almost 100 solar masses.

Radiation pressure is blasting off the outer parts.