Star in a Box Worksheet - Intermediate

☆ Launch Star in a Box and open the lid. The main plot is a Hertzsprung-Russell diagram. On the right, the information panel allows comparisons between the radius, surface temperature and luminosity of the star relative to the Sun.The starting parameters are for a star like the Sun.

A. *Download the CSV file for a 1 solar mass star and open it in a spreadsheet. Plot graphs of mass, luminosity, radius and surface temperature against time.*

1. Describe how the luminosity changes with time. Luminosity remains mostly constant at about 1 L_{Sun} until about 10,000 Myr, when it abruptly and briefly increases to over 4500 times L_{Sun}.
2. Describe how the radius changes with time. Radius is mostly constant at about 1 R_{Sun} until about 10,000 Myr, when it abruptly and briefly increases to over 200 times R_{Sun}.
3. How does the mass of the star change with time? The mass remains mostly constant until about 10,000 Myr, the abruptly drops to <0.55 M_{Sun} and remains mostly constant there.
4. What do you think happens to the rest of the mass? The rest of the mass is ripped off the star and forms a planetary nebula when the star collapses into a white dwarf.

B. *Some of the changes in luminosity and temperature are very sudden. What do you think might be happening within the star at these changes?*

- Changes in the dominant type of fusion
- Collapse

C. *Download the CSV file for a 30 solar mass star, open it in a spreadsheet, and plot the same graphs as in section A.*

1. How do these graphs compare with the 1 solar mass star? The time scale is very different...10,000 Myr vs 10. The luminosity graph looks very different from the 1 Solar mass. The 30 solar mass spends most of its life slowly increasing in brightness, while the 1 solar mass star has much more constant luminosity over its long life.
2. How are the compositions of the two stars changing over their life times? The larger star uses more of its fuel and its mass goes down visibly on the graph. The 1 solar mass star appears to lose very little

mass while on the main sequence. Presumably the larger amount of mass means there is more mass to be lost during the fusion process.

D. *Betelguese is 20 times the mass of the Sun and very near the end of its life.*

1. It is 197 parsecs (640 light years) away, but how many magnitudes brighter than the Sun would it look if both stars were 10 parsecs (32.6 light years) away?

Using absolute magnitude:

$$M_{Betelgeuse} = M_{Sun} - 2.5\log_{10}(L_{Betelgeuse}/L_{Sun})$$

$$M_{Betelgeuse} = 4.74 - 2.5\log_{10}(149{,}245.07\ L_{Sun}/L_{Sun})$$

$$M_{Betelgeuse} = -8.20$$

So Betelgeuse would appear 12.94 magnitudes brighter than the Sun at that distance.

2. If Betelgeuse were at the location of our Sun, how large would it be compared with the orbit of the planets?

R_{Sun} = 695,500 km

$R_{Betelgeuse}$ = 1222.08 × R_{Sun}

$R_{Betelgeuse}$ = 8.50 × 10^8 km

For comparison, Jupiter's average distance from the Sun is 7.783 × 10^8 km, and Saturn's is 1.432 × 10^9 km, so the surface of Betelgeuse would likely extend to at least Jupiter's orbit and probably somewhat beyond.