

Astronomy C

SSSS 2017



Type II Supernovae and Stellar Evolution

School: _____

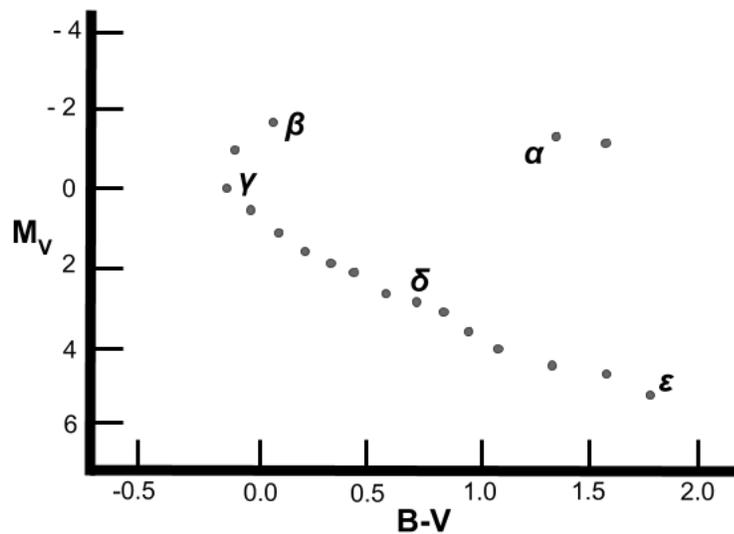
Team #: _____

Names: _____

Instructions: This test includes free-response, math/physics, and multiple choice questions. However, it does not include any DSO's, as the test was written before they were announced. Record your answers on the answer sheet. The test is out of 100 points and scoring for individual questions can be found on the answer sheet.

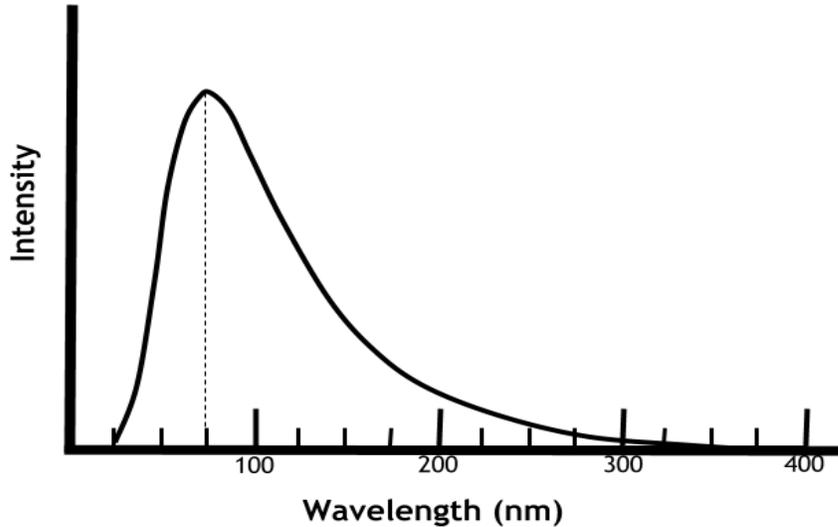
1. A 150 solar mass star is observed in a galaxy over 12 billion light years from Earth.
 - a) Which stellar population does it belong to?
 - b) The formation of stars of this mass has never been observed. Why?
 - c) How does this star's metallicity likely compare to that of the sun (greater than, same, less than)?
 - d) What is the primary fusion process that occurs in this star while it is on the main sequence?
 - e) What is the Eddington Limit for this star (in Watts)?
 - f) What would happen if the star were to exceed the Eddington Limit?

2. The following diagram displays a star cluster. The cluster has a parallax of 0.0067 arcsec.



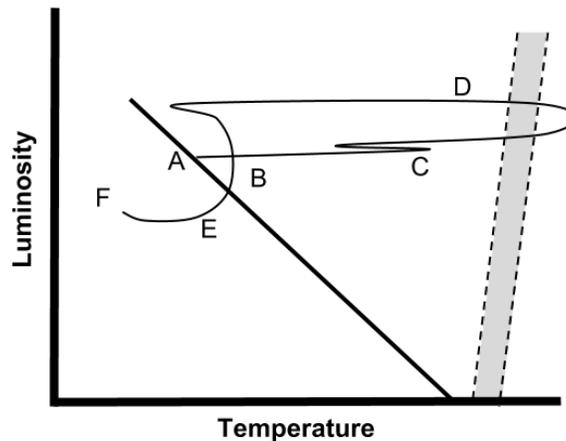
- a) What type of diagram is this?
- b) How far away is this star cluster (in parsecs)?
- c) What does the star marked γ signify?
- d) What is the name of the absence of stars between α and β ?
- e) Why do we not observe stars in this gap?
- f) What type of cluster is shown?
- g) Where in the Milky Way are you most likely to observe this type of cluster?
- h) If this cluster is surrounded by dust clouds, what type of nebula would be observed?
- i) If you wanted to determine the age of the cluster, which star would be the most useful?

3. A Wolf Rayet (WR) star is observed with an absolute magnitude of -3.5 . Its peak wavelength is shown below.



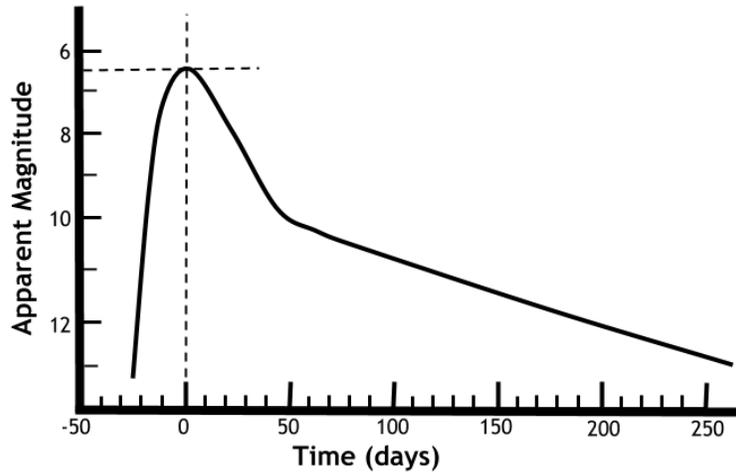
- What is the luminosity of this star (in solar luminosities)?
- What is the temperature of this star (in K)?
- What is the radius of this star (in solar radii)?
- WR stars often display a P Cygni profile. What does this signify?
- Why do WR stars lack hydrogen?
- WR stars have similar distributions throughout galaxies as O-type stars. What might this imply?
- How will this star end (be specific!)?

4. The following HR diagram displays the evolutionary path of a 60 solar mass star.



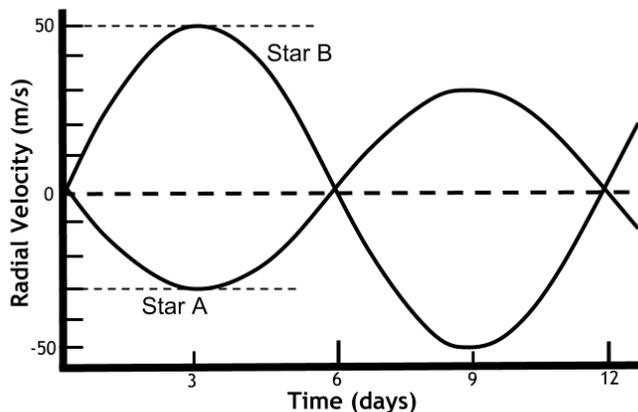
- What does the diagonal line signify?
- What does the shaded region signify?
- What property do all stars in this region share?
- What stage of evolution is the star at point C?
- What stage of evolution is the star at point D?
- What stage of evolution is the star at point E?
- At which letter is the star at its coolest?
- At which letter does the star experience the most mass loss?
- What event occurs at point F?

5. This light curve was created following a supernova. Its absolute magnitude was determined to be -17.5.



- What type of supernova is this? Be as specific as possible!
- What was the last element produced in this star's lifetime?
- Why does fusion of this element not support the star?
- What two processes contribute to the sudden drop in core pressure that results in collapse?
- What form of radiation is the majority of the supernova's energy released as?
- How far away did the supernova occur (in pcs)?
- Based on this estimate, the supernova most likely originated in:
 - Milky Way
 - Large Magellanic Cloud
 - Andromeda Galaxy
 - Outside the Virgo Supercluster

6. This graph displays the radial velocity of a binary neutron star system. The total mass of the system is 4.8 solar masses.

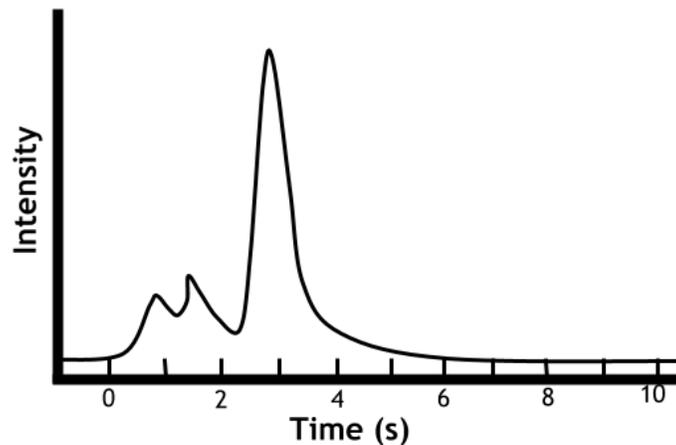


- What is the system's period?
- What is the mass ratio of star A to star B?
- What is the separation between the two stars (in AU)?
- Which of the two stars has a smaller radius?
- As the system ages, the emission of what causes the orbits to decay?
- This phenomenon provides support for which theory?
 - Neutron Degeneracy
 - Vogt-Russell Theorem
 - Special Relativity
 - General Relativity
- When the two stars merge, what high-energy event might we observe?

7. A 1.9 solar mass pulsar is observed with a period of 40 ms. It has a radius of 12 km and a luminosity of 2.2×10^{32} watts.

- a) At what rate is the pulsar slowing down (in sec/sec)?
- b) What principle explains the pulsar's extremely short period?
- c) Nuclear fusion is no longer occurring in the pulsar. What source of pressure supports the neutron star's mass?
- d) What is the name of the upper limit for a neutron star?
- e) What is the source of radiation that powers the pulsar's X-ray beams?
- f) What is the term for an abrupt change in a pulsar's period?
- g) The pulsar is engulfed by its companion and now orbits inside a giant star. What might this new object be called?

8. A Gamma Ray Burst (GRB) was detected in a distant galaxy.



- a) Name one NASA telescope used to detect GRB's.
- b) What type of GRB is this?
- c) What is the most likely progenitor for this type of GRB?
- d) What evidence supports this model?
- e) GRB's have been proposed as an explanation for which ecological events on Earth?
- f) Name one GRB candidate in the Milky Way.

9. A black hole is formed following a supernova explosion.
- a) What is the minimum mass of the progenitor star?
 - b) The black hole's actual mass is 35 solar masses. What is the Schwarzschild radius of the resulting black hole (in km)?
 - c) Black holes are not entirely black; what type of radiation do they emit?
 - d) A Saturn V rocket (110 m tall and 2.97 million kg) ventures too close to the black hole. What are the tidal forces experienced by the rocket 1000 km away from the black hole (in Newtons)?
 - e) What comical term is used to describe the effect of the tidal forces?

Miscellaneous:

- a) If the Milky Way were the size of Earth, how far away would the Andromeda Galaxy be? How do you know (hint: no math is necessary)?
 - A)The Moon B)Venus C)Sun D)Alpha Centauri E)The galactic center
- b) Name the star on the front page of the test.
- c) Name one woman and her contribution to astronomy.
- d) In 2018, NASA plans to launch the James Webb Space Telescope with the goal of learning about the formation of both stars and galaxies. In order to accomplish these goals, what wavelength of light should the telescope observe in? Why?