

OpenStax Astronomy, Ch.23: WS Problems (Apr-2021)

Review Questions

1. How does a white dwarf differ from a neutron star? How does each form? What keeps each from collapsing under its own weight?
2. Describe the evolution of a star with a mass like that of the Sun, from the main-sequence phase of its evolution until it becomes a white dwarf.
3. Describe the evolution of a massive star (say, 20 times the mass of the Sun) up to the point at which it becomes a supernova. How does the evolution of a massive star differ from that of the Sun? Why?
4. How do the two types of supernovae discussed in this chapter differ? What kind of star gives rise to each type?
5. A star begins its life with a mass of $5 M_{\text{Sun}}$ but ends its life as a white dwarf with a mass of $0.8 M_{\text{Sun}}$. List the stages in the star's life during which it most likely lost some of the mass it started with. How did mass loss occur in each stage?
6. If the formation of a neutron star leads to a supernova explosion, explain why only three of the hundreds of known pulsars are found in supernova remnants.
7. How can the Crab Nebula shine with the energy of something like 100,000 Suns when the star that formed the nebula exploded almost 1000 years ago? Who "pays the bills" for much of the radiation we see coming from the nebula?
8. How is a nova different from a type Ia supernova? How does it differ from a type II supernova?
9. What observations from SN 1987A helped confirm theories about supernovae?
10. Describe the evolution of a white dwarf over time, in particular how the luminosity, temperature, and radius change.
11. Describe the evolution of a pulsar over time, in particular how the rotation and pulse signal changes over time.
12. How would a white dwarf that formed from a star that had an initial mass of $1 M_{\text{Sun}}$ be different from a white dwarf that formed from a star that had an initial mass of $9 M_{\text{Sun}}$?
13. What do astronomers think are the causes of longer-duration gamma-ray bursts and shorter-duration gamma-ray bursts?
14. How did astronomers finally solve the mystery of what gamma-ray bursts were? What instruments were required to find the solution?
15. Arrange the following stars in order of their evolution:
 - A. A star with no nuclear reactions going on in the core, which is made primarily of carbon and oxygen.
 - B. A star of uniform composition from center to surface; it contains hydrogen but has no nuclear reactions going on in the core.
 - C. A star that is fusing hydrogen to form helium in its core.
 - D. A star that is fusing helium to carbon in the core and hydrogen to helium in a shell around the core.

- E. A star that has no nuclear reactions going on in the core but is fusing hydrogen to form helium in a shell around the core.

16. Suppose no stars more massive than about $2 M_{\text{Sun}}$ had ever formed. Would life as we know it have been able to develop? Why or why not?

17. Would you be more likely to observe a type II supernova (the explosion of a massive star) in a globular cluster or in an open cluster? Why?

18. If most stars become white dwarfs at the ends of their lives and the formation of white dwarfs is accompanied by the production of a planetary nebula, why are there more white dwarfs than planetary nebulae in the Galaxy?

19. If a 3 and 8 M_{Sun} star formed together in a binary system, which star would:

- A. Evolve off the main sequence first?
- B. Form a carbon- and oxygen-rich white dwarf?
- C. Be the location for a nova explosion?

20. You have discovered two star clusters. The first cluster contains mainly main-sequence stars, along with some red giant stars and a few white dwarfs. The second cluster also contains mainly main-sequence stars, along with some red giant stars, and a few neutron stars—but no white dwarf stars. What are the relative ages of the clusters? How did you determine your answer?

21. How would the spectra of a type II supernova be different from a type Ia supernova? Hint: Consider the characteristics of the objects that are their source.

22. One way to calculate the radius of a star is to use its luminosity and temperature and assume that the star radiates approximately like a blackbody. Astronomers have measured the characteristics of central stars of planetary nebulae and have found that a typical central star is 16 times as luminous and 20 times as hot (about 110,000 K) as the Sun. Find the radius in terms of the Sun's. How does this radius compare with that of a typical white dwarf?

23. According to a model described in the text, a neutron star has a radius of about 10 km. Assume that the pulses occur once per rotation. According to Einstein's theory of relativity, nothing can move faster than the speed of light. Check to make sure that this pulsar model does not violate relativity. Calculate the rotation speed of the Crab Nebula pulsar at its equator, given its period of 0.033 s. (Remember that distance equals velocity $\times$ time and that the circumference of a circle is given by $2\pi R$).

24. Before the star that became SN 1987A exploded, it evolved from a red supergiant to a blue supergiant while remaining at the same luminosity. As a red supergiant, its surface temperature would have been approximately 4000 K, while as a blue supergiant, its surface temperature was 16,000 K. How much did the radius change as it evolved from a red to a blue supergiant?