12.15: The Death of Stars (Exercises)

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_{Sun} but ends its life as a white dwarf with a mass of 0.8 M_{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. Apart from the masses, how are binary systems with a neutron star different from binary systems with a white dwarf?
10. What observations from SN 1987A helped confirm theories about supernovae?
11. Describe the evolution of a white dwarf over time, in particular how the luminosity, temperature, and radius change.
12. Describe the evolution of a pulsar over time, in particular how the rotation and pulse signal changes over time.
13. How would a white dwarf that formed from a star that had an initial mass of 1 M_{Sun} be different from a white dwarf that formed from a star that had an initial mass of 9 M_{Sun}?
14. What do astronomers think are the causes of longer-duration gamma-ray bursts and shorter-duration gamma-ray bursts?
15. How did astronomers finally solve the mystery of what gamma-ray bursts were? What instruments were required to find the solution?

Thought Questions

1. Arrange the following stars in order of their evolution:
    1. A star with no nuclear reactions going on in the core, which is made primarily of carbon and oxygen.
    2. A star of uniform composition from center to surface; it contains hydrogen but has no nuclear reactions going on in the core.
    3. A star that is fusing hydrogen to form helium in its core.
    4. A star that is fusing helium to carbon in the core and hydrogen to helium in a shell around the core.
    5. 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.
2. Would you expect to find any white dwarfs in the Orion Nebula? Why or why not?
3. 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?
4. 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?
5. Astronomers believe there are something like 100 million neutron stars in the Galaxy, yet we have only found about 2000 pulsars in the Milky Way. Give several reasons these numbers are so different. Explain each reason.
6. Would you expect to observe every supernova in our own Galaxy? Why or why not?
7. The Large Magellanic Cloud has about one-tenth the number of stars found in our own Galaxy. Suppose the mix of high- and low-mass stars is exactly the same in both galaxies. Approximately how often does a supernova occur in the Large Magellanic Cloud?
8. Look at the list of the nearest stars in Appendix I. Would you expect any of these to become supernovae? Why or why not?
9. 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?
10. If a 3 and 8 M_{Sun} star formed together in a binary system, which star would:
    1. Evolve off the main sequence first?
    2. Form a carbon- and oxygen-rich white dwarf?

3. Be the location for a nova explosion?

11. A supernova remnant was recently discovered and found to be approximately 150 years old. Provide possible reasons that this supernova explosion escaped detection.
12. Based upon the evolution of stars, place the following elements in order of least to most common in the Galaxy: gold, carbon, neon. What aspects of stellar evolution formed the basis for how you ordered the elements?
13. What observations or types of telescopes would you use to distinguish a binary system that includes a main-sequence star and a white dwarf star from one containing a main-sequence star and a neutron star?
14. 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.
