## PROBLEM SET 7 Physics 2022

1. The central star in a newly formed planetary nebula has a luminosity of 1000  $L_{\odot}$  and a surface temperature of 100,000 K. What is the star's radius? Give your answer as a multiple of the Sun's radius.

2. The Ring Nebula in the constellation Lyra has an angular size of 1.2 arcmin x 1.2 arcmin. It is expanding at the rate of about 20 km/s. Approximately how long ago did the central star shed its outer layers? Assume that the nebula is 2,700 ly from Earth.

3. (a) Calculate the wavelength of maximum emission of the white dwarf Sirius B if its surface T = 30,000 K. In what part of the electromagnetic spectrum does this wavelength lie? (b) In a visible-light photograph, Sirius B appears much fainter than its primary star. But in an image made with an X-ray telescope, Sirius B is the brighter star. Explain the difference.

4. Find the average density  $(g/cm^3)$  of a 1-M<sub> $\odot$ </sub> white dwarf having the same diameter as the Earth.

5. In the classic 1960's science-fiction comic book *The Atom*, a physicist discovers a basketballsized meteorite (about 10 cm in radius) that is actually a fragment of a white dwarf star. With some difficulty, he manages to hand-carry the meteorite back to his laboratory. Estimate the mass of such a fragment, and discuss the plausibility of this scenario.

6. Suppose that the brightness of a star becoming a supernova increases by 20 magnitudes. Show that this corresponds to an increase of  $10^8$  in luminosity.

7. Suppose that the red-supergiant star Betelgeuse, which lies some 425 light-years from the Earth, becomes a Type II supernova. At the height of the outburst, what would its apparent magnitude be? (*Hint*: The absolute magnitude of this kind of supernova is -17.0 magnitudes.)

8. In July 1997, a supernova named SN 1997 CW exploded in the galaxy NGC 105 in the constellation Cetus the Whale. It reached an apparent magnitude of +16.5 at maximum brilliance, and its spectrum showed no hydrogen lines. That means it is a Type Ia supernova and its absolute magnitude is -19.0 magnitudes. Compute its distance (in Mpc).