Homework 14

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1. Formula given: $t_{ff} = \sqrt{(\frac{3\pi}{32})(\frac{1}{G\rho_0})}$. Then,

$$\begin{aligned} t_{ff} &= \sqrt{(\frac{3\pi}{32})(\frac{1}{(6.674 * 10^{-11})(10^{13})})} \\ &= \sqrt{4.41 * 10^{-4}} \\ &= 0.021 \text{ s} \end{aligned}$$

2. (a) Dimensions: $s = r\theta$
   Major axis: $s = \frac{4\pi}{10800} * 2400 = 2.8$ pc
   Minor axis: $s = \frac{2\pi}{10800} * 2400 = 1.4$ pc
   Linear dimensions are 2.8 pc x1.4 pc

   (b) Age: $t = \frac{s}{2v}$. Then

$$\begin{aligned} t &= \frac{s}{2v} \\ &= \frac{2.8(3.09 * 10^{13}}{2(1400)} \\ &= 3.09 * 10^{10} \text{ s} \\ &= 979 \text{ years.} \end{aligned}$$

3. Magnitude: $m - M = 5 \log \frac{d}{10}$. Then,

$$\begin{aligned} m - (-17.5) &= 5 \log \frac{2400}{10} \\ m &= 5 \log 240 - 17.5 \\ &= -5.60. \end{aligned}$$

   Comparing brightness using apparent magnitude: $\frac{F_2}{F_1} = 100^{\frac{(m_1 - m_2)}{5}}$. Then,

$$\begin{aligned} \frac{F_{Crab}}{F_{Venus}} &= 100^{\frac{(-4-(-5.60)}{5}} \\ &= 4.37. \end{aligned}$$

   Therefore, the Crab Nebula is 4.37 times brighter than Venus.

4. The distance of SN 1986A according to a brief Google search is $d = 51.4$ kpc. Energy during supernova: $E = 4\pi d^2(E_{avg})(A)$. Then,

$$E = 4\pi(51.4(3.08 * 10^{19}))^2(1.4(1.602 * 10^{-19}))(1.5 * 10^{14})$$
$$E = 1.06 * 10^{45} \text{ J}$$