16 Astro notes 2018/9/28 - Fri - Star formation

Some discussion of exam and homework just turned in.

discussed boost direction in doppler boost question and pressure balance in ISM question.

16.1 HR and CM diagrams

Note tha the H-R diagram (based on stellar observations) is more typically thought of as a Luminosity-Temperature diagram.

Note that this is also a T - R diagram since $L = 4\pi R^2 \sigma T^4$.

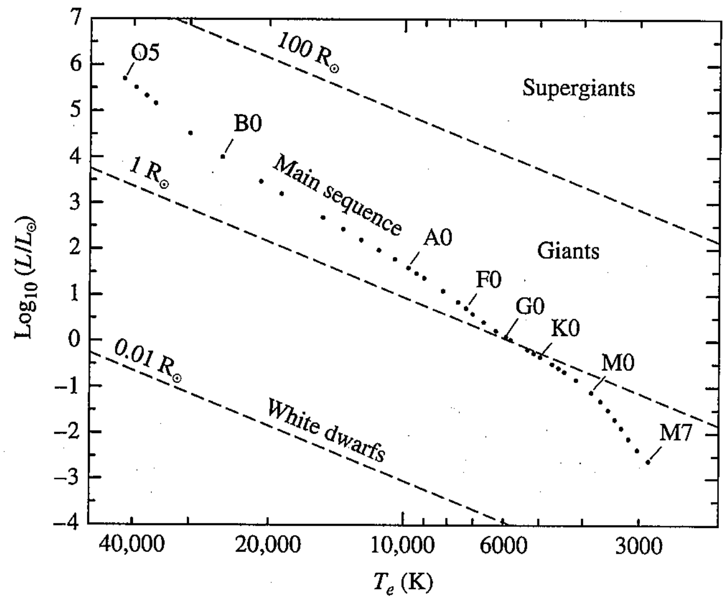


FIGURE 8.14 The theorist's Hertzsprung–Russell diagram. The dashed lines indicate lines of constant radius.

Also can compare to a color-magnitude diagram, shown in 8.13.

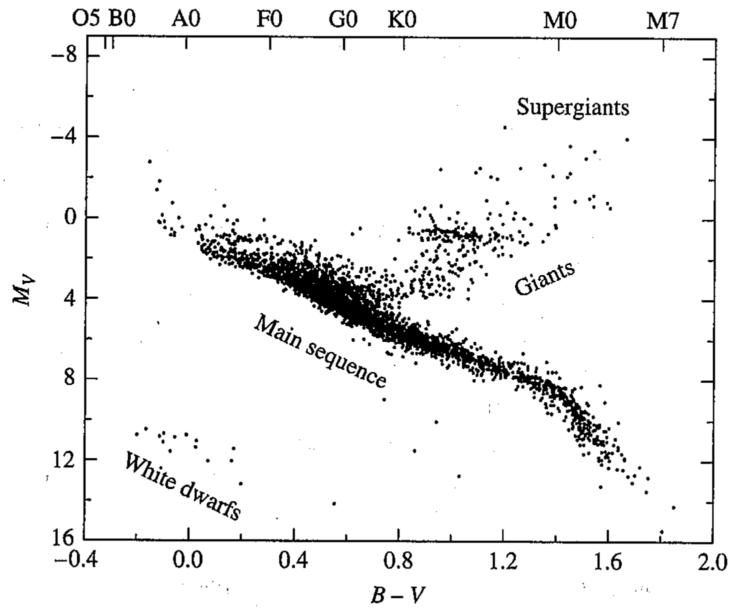


FIGURE 8.13 An observer's H–R diagram. The data are from the Hipparcos catalog. More than 3700 stars are included here with parallax measurements determined to better than 20%. (Data courtesy of the European Space Agency.)

Color, being a ratio of fluxes, indicates the slope of the spectrum, and is therefore fairly monotonically dependent on temperature. It is easier to measure two broad-band fluxes to get color, so it is common to have many stars on color-magnitude diagram. For nearby stars the magnitude is absolute magnitude (since the distance can be measured) while for clusters often just the magnitude in one of the bands used for the color is used, since all the stars are at the same distance.

16.2 Star formation and Jean's mass

Take a piece of the ISM with density ρ and T which has mass M over radius R. the gravitational energy is

$$E_{GR} \sim -\frac{GM^2}{R}$$

Typical densities in a star forming clound are $n \simeq 100/\text{cc}$.

Want to ask: for a known density n and temperature T of a cloud, how big (in mass) does the cloud need to be to collapse under its own gravity?

Total KE content of that region is

$$E_{th} \simeq \frac{3}{2}\frac{M}{m_p}kT$$

critical condition (Jeans length or Jeans mass) set by

$$E_{GR} + E_{th} < 0$$

i.e. when cloud is bound.
(student): put in and eliminate R in favor of $\rho = m_p n$
Putting in the energies this is

$$\frac{GM^2}{R} > \frac{3}{2}\frac{M}{m_p}kT$$

Rewrite in terms of density

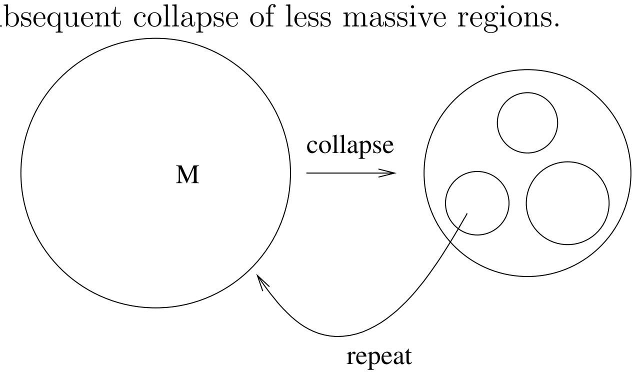
$$M = \frac{4\pi}{3}R^3\rho$$

or

$$M_J = 500M_\odot \left(\frac{T}{10^4\ \mathrm{K}}\right)^{3/2} \left(\frac{1\ \mathrm{cm}^{-3}}{n}\right)^{1/2}$$

where $n = \rho/m_p$. In a region with T, ρ a mass in excess of this can collapse.

The problem is this is big. How do we get from this to the distribution of stellar masses from this? How does a collapsing mass fragment into $M_\odot$ chunks? We will simply try to answer why would it fragment at all? The Jean's mass scales as $M_J \propto T^{3/2}\rho^{-1/2}$. Imagine that the region keeps it's same temperuture as it collopses. Then M_J decreases during the collapse. Then as the jeans mass decreases this can allow for "fragmentation" or the subsequent collapse of less massive regions.



Next time we'll talk about halting fragmentation to get stars.