Lecture 11 : Life History of Stars I
Low Mass Stars

We live in exciting times! As NASA reveals the first images from the James Webb Space Telescope (JWST), we are treated with hitherto unseen views of our Universe. An astronomical (!) number of newly born stars can now be 'seen' glittering through the curtain of dust and gas in the young star-forming region of NGC 3324 in the Carina Nebula. [Credits: NASA, ESA, CSA, and STScI]

All stars are born from giant clouds of gas, like that seen in the image above. But their life history depends crucially depends upon their mass. The larger its mass, the shorter its life cycle. This lecture focuses on the evolution of low mass stars, similar to the Sun, which live for a very long time. It also discusses why why such stars evolve to become giants, and then supergiants and what becomes of them in the end.

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Suggested Texts

1. S. Chandrasekhar, 1939, ***An Introduction to the Study of Stellar Structure***, Dover Books on Astronomy
2. D. D. Clayton, 1983, ***Principles of Stellar Evolution and Nucleosynthesis***, The University of Chicago Press
3. R. Kippenhahn & A. Weigert, 1990, ***Stellar Structure and Evolution***, Springer

Suggested Problems

1. ρ-T Plane : Consider a gas of ionised hydrogen. In the $\rho - T$ plane calculate the approximate boundary lines between regions where :
   (a) radiation pressure dominates,
   (b) the electrons behave like a classical ideal gas,
   (c) the electrons behave like a degenerate quantum gas,
   (d) the electrons are degenerate.

   What is the state of the electron gas inside a terrestrial piece of iron at room temperature? In the central region of a star both electrons and ions exist. When we talk the gas becoming degenerate, which particle species is being talked about? Why?
2. The masses of stars are approximately in the range $0.08M_{\odot} < M < 100M_{\odot}$. Can you think of the reason why there should be an upper and a lower limit?
3. H-R Diagram : Use a thermodynamic principle to draw lines of *constant radius* in the Hertzsprung-Russel diagram. Comment upon the average stellar density across the range of stellar masses from this.
4. The evolutionary timescale of stars are inversely related to their masses, ie., the lowest mass stars live the longest. Why should that be so?
5. Assume the inert He core of a low-mass star to have the same temperature as the Hydrogen shell that is burning outside of it. Find the maximum possible radius of this core if it happens to be degenerate and has a mass of $0.45M_{\odot}$. What would be the total gravitational energy release for the core to attain this radius? If the degeneracy of this core is to be lifted, what should be its minimum temperature?

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