1 Summary quiz of lecture 1

In the first part of the lecture, stellar structure, nuclear reaction rates, hydrogen burning were introduced and discussed in detail. This first exercise sheet is meant as a review for you to recall your knowledge and to fill gaps. The first exercise session can also be used to discuss any unclear topics again.

(a) Polytropes: Recall the stellar structure equations.
   • Why is it necessary to introduce an additional constraint like the polytrope model to solve this system of equations?
   • What polytropic index $n$ would you use to model e.g. a mail sequence star, a white dwarf, or a neutron star?
   • How does an increasing polytropic index $n$ influence the density distribution of the star?

(b) Degeneracy:
   • What is degenerate matter?
   • How does the pressure of a degenerate gas react to a change in temperature?
   • In what types of stars do we expect degeneracy of which particles?

(c) Life of stars:
   • What is the typical mass range of stars?
   • Discuss the variation of lifetime and luminosity for this range!
   • What are the remnants (last stage of evolution) of stars with 1$M_\odot$ and 10$M_\odot$ and why do they differ?
   • Why can an observed helium white dwarf not be the result of a 'standard' stellar evolution of a single star?
   • Can a binary system consisting of a 1.2$M_\odot$ white dwarf and a 0.15$M_\odot$ main-sequence companion go supernova? Discuss!

(d) Non-resonant reaction rates:
   • What is a Gamow-Window and how is it obtained for a specific reaction?
   • How can the introduction of the astrophysical S-factor help to extrapolate reaction rates down to astrophysical energy ranges?

(e) Resonant reaction rates:
   • What is the concept behind a resonant reaction?
   • At a given temperature $T$, how can you find out which resonances can contribute to a specific reaction rate?
   • What factors besides $T$ need to be considered for that?
   • What is a sub-threshold resonance and how can it influence a reaction rate?

(f) Hydrogen burning:
   • What stars will predominantly burn hydrogen via the CNO cycle?
   • Which is the slowest reaction in the p-p chain?
   • Why is it so slow and is this critical for life on earth?
   • Compare the temperature dependence of the energy generation rate of CNO burning to p-p burning!