

Exercises for Nuclear Astrophysics II - SS 2012

Sheet 1

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Phone: 089/289/14273 - Discussion of this exercise: 04/26/2011 @ 1 p.m.

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 main 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 $1M_{\odot}$ and $10M_{\odot}$ 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 $1.2M_{\odot}$ white dwarf and a $0.15M_{\odot}$ 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!