

Updated figures for AST3220 project 2 – BBN

Jakob Borg

April 3, 2024

This is a collection of updated figures for project 2, Big Bang Nucleosynthesis. For completeness figs. 1 and 2 are included although the results are identical to those in the original project description. Note however that the colors used for each species are changed to reduce the danger of interchanging the figures, and to keep the colors used for each species consistent through all figures. The total mass fraction summed over the contributing species is included as the horizontal dotted black line in figs. 1 to 3.

The main motivation for this updated collection is in figs. 3 to 5, where an unknown problem in the original code of the previous teaching assistant caused some issues. This is particularly evident in the abundance of Be^7 and in the parameter optimization in figs. 4 and 5. Compared to the original results, this new solution has a slightly lower Be^7 abundance, which of course also effects the abundance of the other species (though the effect is hard to see by eye). This propagates through to the parameter optimization, where now the best fitting parameters also match the observed Li^7 abundance from today, where the original results did not.

List of Figures

1	Figure to problem f	2
2	Figure to problem h	3
3	Figure to problem i	4
4	Figure to problem j	5
5	Figure to problem k	6

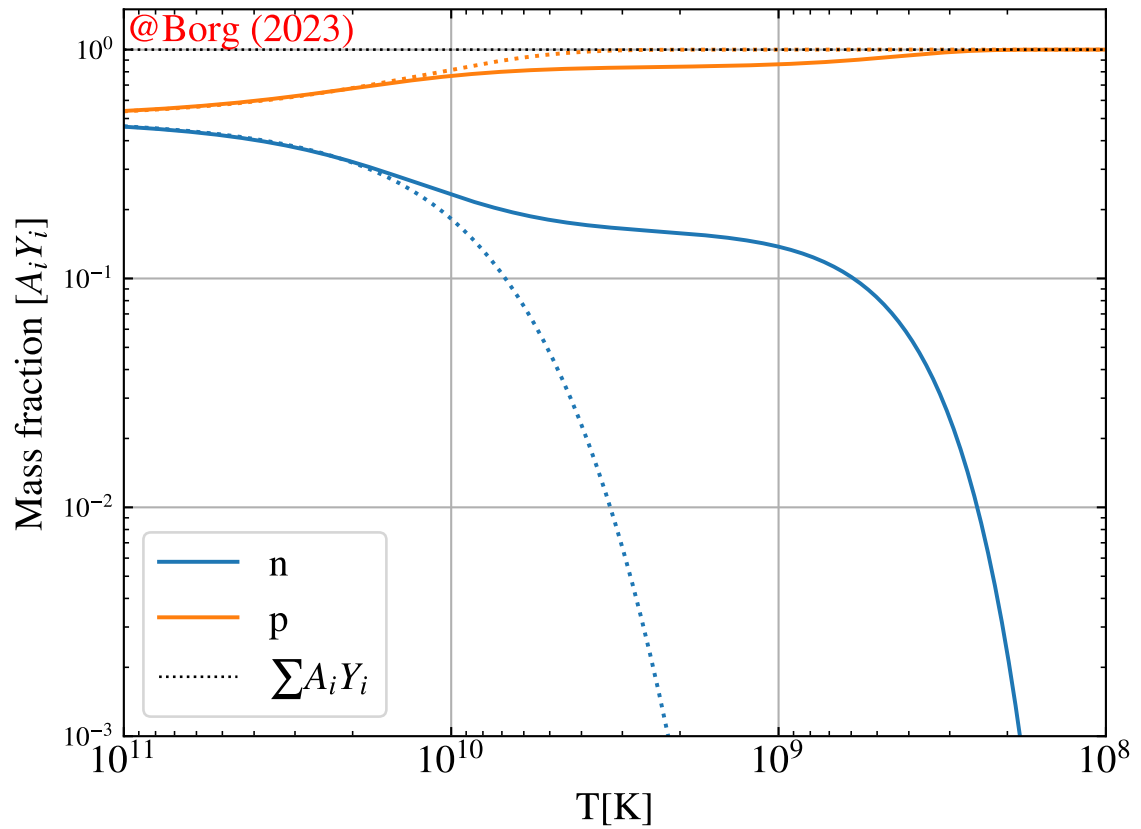


Figure 1: *Problem f.* The solution of Y_n and Y_p from eqs. (10) and (11), shown in solid lines, as well as the equilibrium values from eqs. (16) and (17), shown in dotted lines.

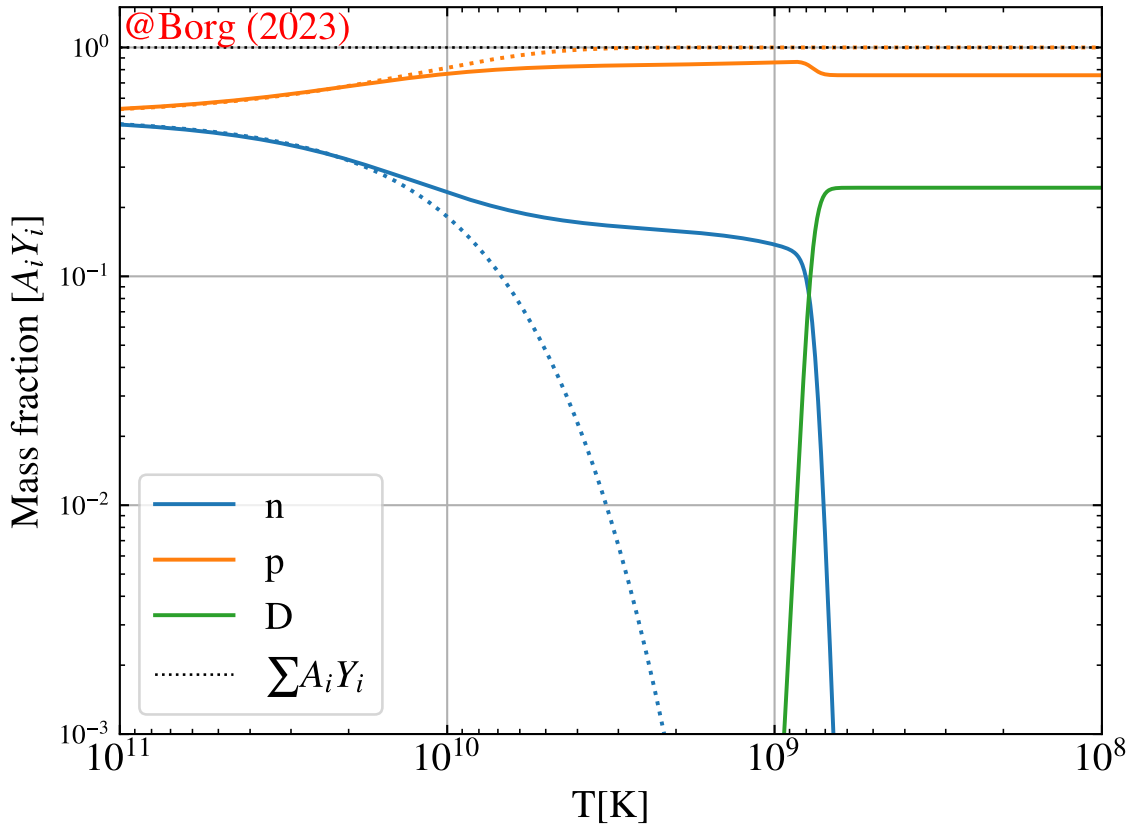


Figure 2: *Problem h.* The solution of Y_n , Y_p , and $2Y_D$ from eqs. (20), (21), and (22), shown in solid, as well as the equilibrium values from eqs. (16) and (17), shown in dotted. We have included the mass number A_i of particle i (i.e. number of neutrons plus protons), such that the fraction of the total baryon mass in the different particle species is shown.

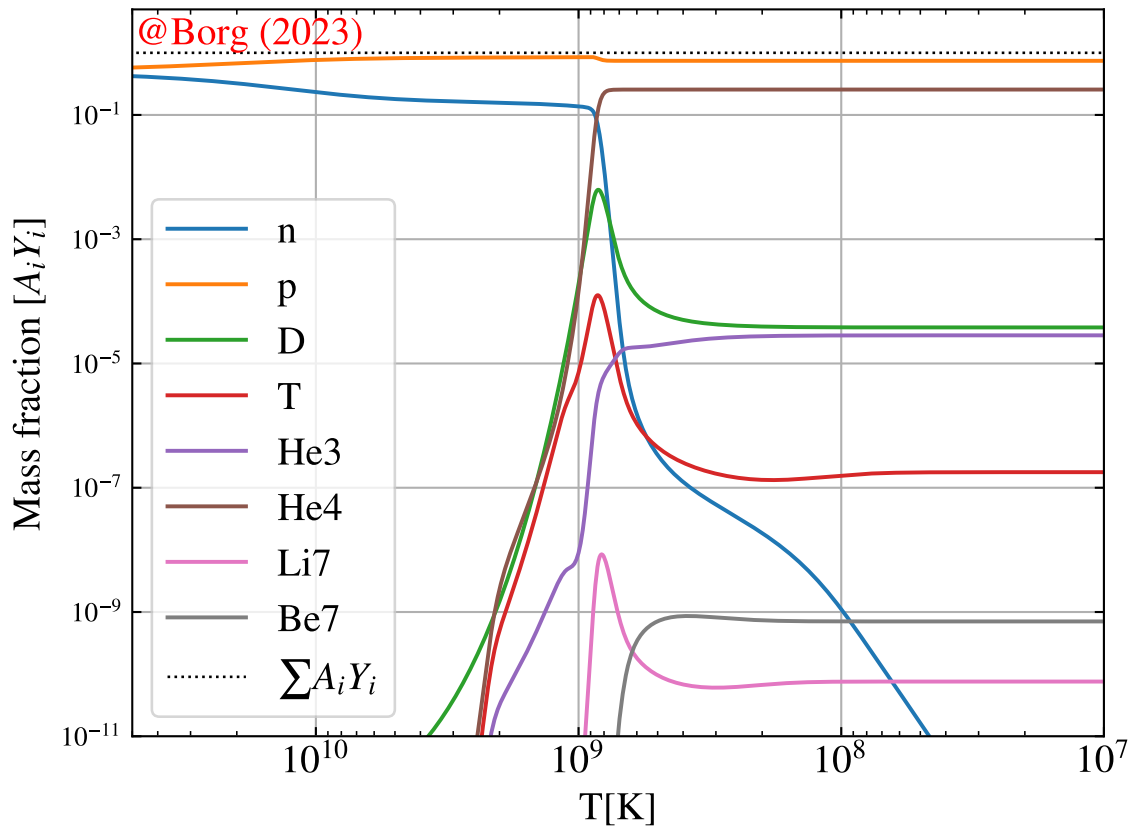


Figure 3: *Problem i.* The mass fractions $A_i Y_i$, where A_i is the mass number of particle i (i.e. number of neutrons plus protons).

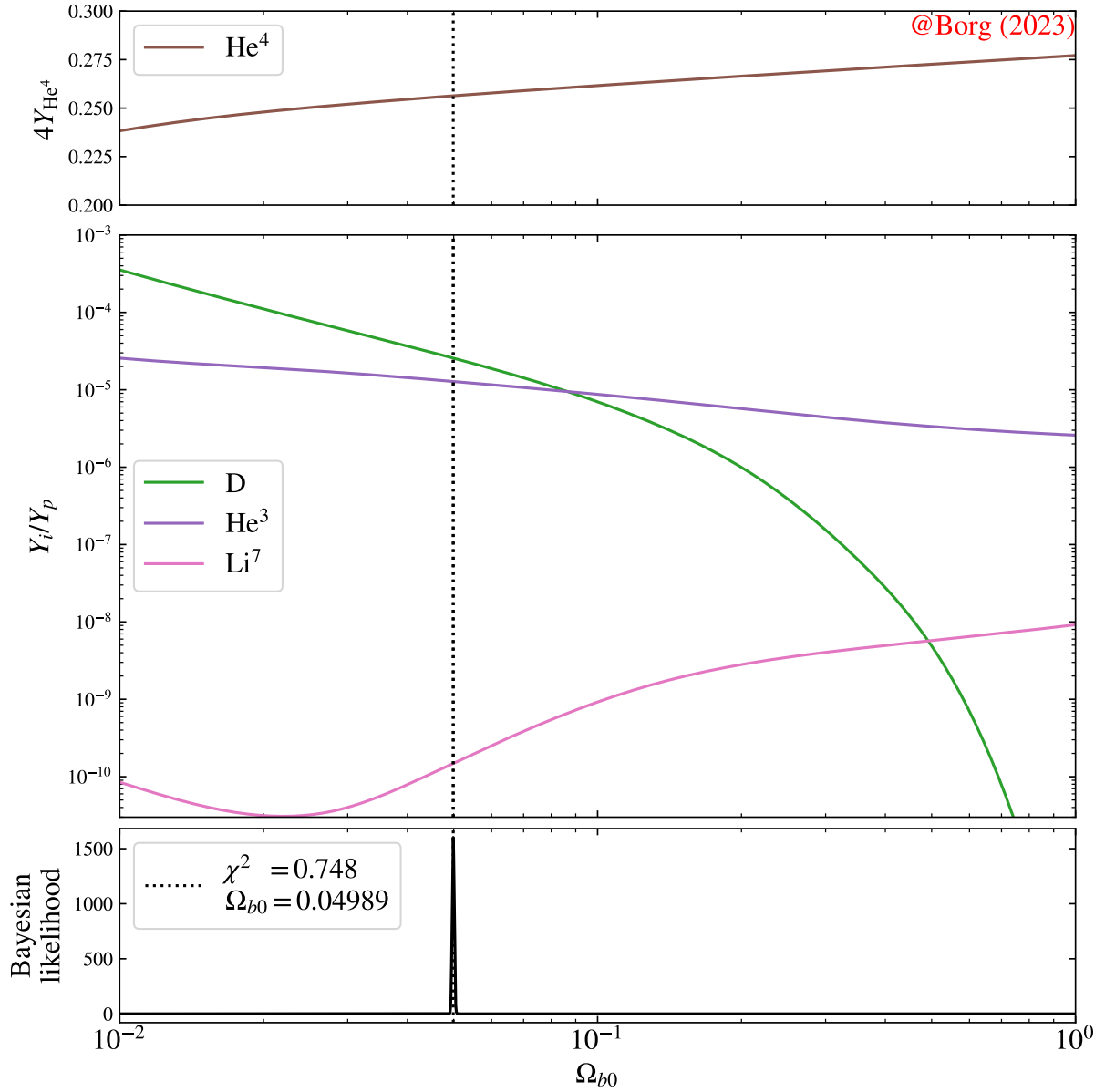


Figure 4: *Problem j.* The relic abundance of elements are shown as a function of the baryon density Ω_{b0} , along with measurements (23), (24), and (25) (horizontal shaded regions). In the lower plot the Bayesian probability eq. (28) is shown. The best-fit value of Ω_{b0} is indicated by the dotted line at the minimum of χ^2 .

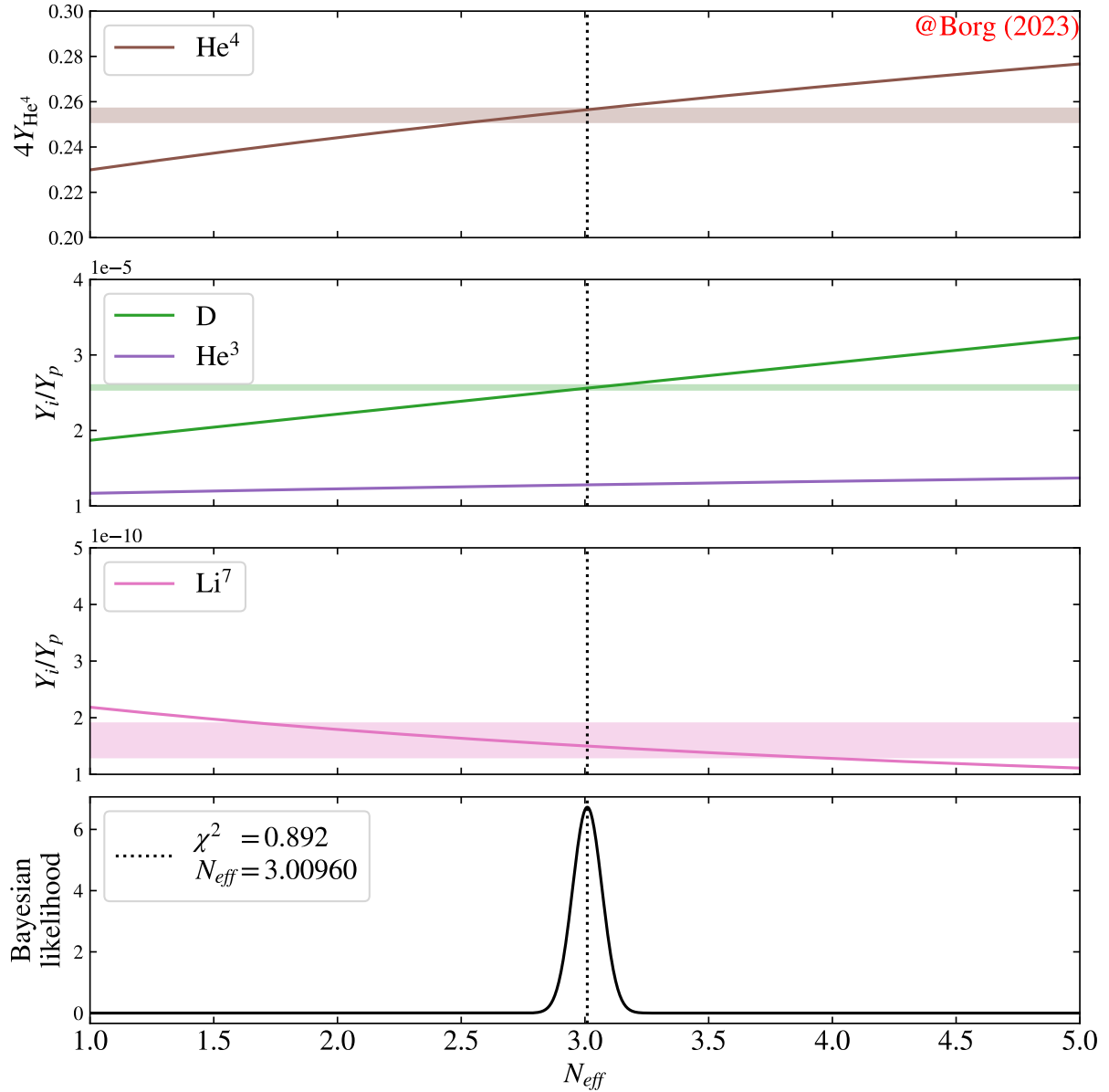


Figure 5: *Problem k.* The relic abundance of elements are shown as a function of the effective number of neutrinos N_{eff} , along with measurements (23), (24), and (25) (horizontal shaded regions). In the lower plot the Bayesian probability eq. (28) is shown. The best-fit value of N_{eff} is indicated by the dotted line at the minimum of χ^2 .