Topic 3:
Nuclear fusion processes in pre-main sequence stars

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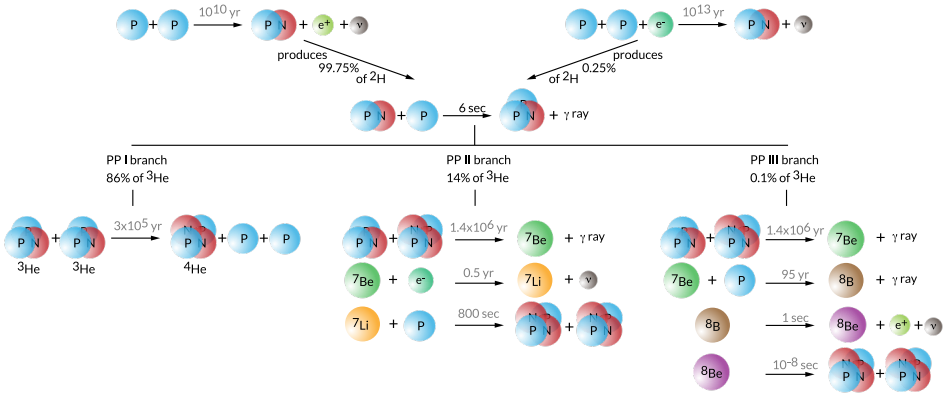
Work focus: *In this bachelor thesis you will calculate stellar models with the stellar evolution code MESA (Modules for Experiments in Stellar Astrophysics, http://mesa.sourceforge.net/). The goal is to investigate the impact of the first nuclear fusion processes during the pre-main sequence phase of stellar evolution and to generate a 'map' of these fusion processes with time.*

One of the major dominating physical effects in the evolution of stars is nuclear fusion. Our Sun, for example, is a main sequence star with the dominating fusion of hydrogen to helium. Stars in later evolutionary phases have exhausted their reservoir of hydrogen. Consequently, other nuclear reaction processes start to dominate, for example helium fusion.

In the stellar youth – before the stars' cores get hot enough to start hydrogen burning – the main energy source is gravitational contraction. This is the evolutionary stage of a star between its birth and the arrival on the zero-age main sequence (ZAMS), i.e., the moment when nuclear fusion from hydrogen to helium becomes the stars' main source of energy. At the beginning of this so-called pre-main sequence phase, the central temperatures are not sufficient yet to start significant nuclear reactions. But once the star reaches high enough temperatures, the first nuclear fusion processes such as the CNO- and PP cycle start.



The weights of the branches are for conditions in the Sun.

The figure to the left illustrates the PP cycle in stars where hydrogen is fused to helium in several steps. Some intermediate steps can already act in the pre-main sequence phase.

In your bachelor thesis you will calculate the nuclear reactions (in particular the CNO- and PP-cycles) acting in late pre-main sequence and early main sequence stars using the open source stellar evolution code MESA. You will also compute the deuterium burning that dominates some parts of the pre-main sequence phases and other interesting reactions.
With these models we will aim to find out which nuclear reactions dominate which stages during the pre-main sequence evolution and try to produce a map that will allow to identify the (relative) evolutionary stage of an object based on its nuclear fusion processes.

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