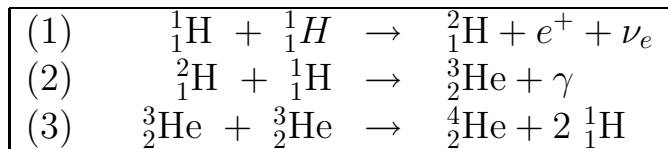


## PHY-105: Summary of Nuclear Reactions in Stars

The most important series of nuclear reactions occurring in stars convert hydrogen to helium. There are two basic reaction chains: the **proton-proton (PP)** chain and the **carbon-nitrogen-oxygen (CNO)** cycle.

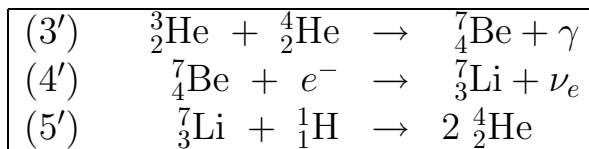
The PP chain divides into three main branches called PP I, PP II, and PP III.

### PP I reaction chain:

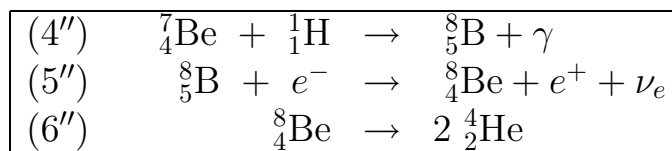


Note that the result of this chain is:  $4 {}^1_1\text{H} \rightarrow {}^4_2\text{He} + 2e^+ + 2\nu_e + 2\gamma$

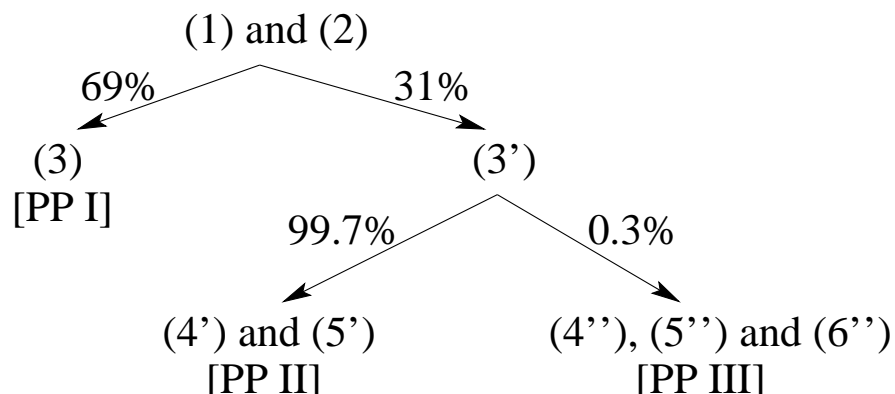
**PP II reaction chain:** this starts with reactions (1) and (2), then:



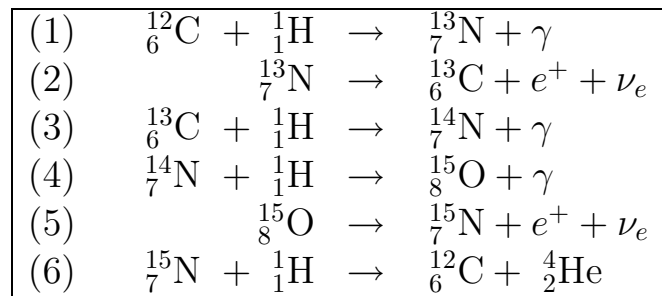
**PP III reaction chain:** this starts with reactions (1), (2) and (3'), then:



In the core of the Sun the following ratios of the PP chains occur:



**CNO cycle** (proposed by Hans Bethe in 1938):



Note that essentially what is happening in the CNO cycle is 4 protons are being added in succession to a carbon nucleus. In two cases (reactions 2 and 5) the addition of the proton is immediately followed by a  $\beta$ -decay, and at the end of the cycle a carbon nucleus remains with a helium nucleus.

**See class notes for more details on these reactions.**