p-process movie:

What is this about ?

Almost 100% of the heavy nuclei are produced by neutron capture processes, because of the high coulomb barrier and the fact that these reactions can not produce energy. But there are 32 stable proton rich nuclei on the right side of the stable valley which are shielded against neutron capture, which can be found in nature.

The p-process is responsible for the origin of the rare proton rich isotopes in nature, which are heavier than iron. The best scenarios for this process are supernova explosions of type II. In these environments very high temperatures (more than 2 billions Kelvin) can be reached when the shock front passes though the O/Ne layers. These p-layers are located far from the core collapse center. So the p-process zones take no notice of the core collapse and see only the out coming shock front. When the shock front reaches the O/Ne layers the density and temperature increase rapidly. Under these conditions the seed nuclei are photodisintegrated (the temperature is high enough that the photons can kick out neutrons, protons, and alpha particles from the nuclei). The nuclei are shifted to the proton rich side of the stable valley first by (γ,n)-reactions. Each lost of a neutron increase the neutron binding energy in the nuclei and the process becomes less effective. At sufficiently high temperatures the synthesis trail can be continued by (γ,p)- and (γ,α)-reactions to lower masses.

The p-process depends strongly on the temperature. In the movie (T9=3.11) you see the influence of the magic shells at neutron numbers 50 and 82. Here the photodisintegration rates are small and thus these nuclei are waiting points for the moving abundances. After the shock front passes the O/Ne layer, the temperature and density drops exponentially and the p-process stops. The stable proton rich nuclei are produced!

Calculation:

Calculated is the abundance evolution during a type II explosion in different Ne/O layers using a complete nuclear reaction network. In the model the s-process seed of a 25 solar mass star was used.

Shown are the results of model calculations for the p-process in two different Ne/O layers reaching temperature up to 3.11 billions Kelvin (Film_T9=3.11), and 2.44 billions Kelvin (Film_T9=2.44), respectively.

Displayed:

Shown is the evolution of the nuclear abundances on the chart of nuclides. Each square is a nucleus - proton number is the vertical axis, neutron number the horizontal axis. The thick framed squares are the stable nuclei. The colors indicate the abundance of the nucleus:

red	>1e-9
yellow	~ 1e-11
green	~ 1e-13
blue	~ 1e-15

Collaboration:

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