ABSTRACT. When a star penetrates deeply into the tidal radius of a black hole, it undergoes a violent and large compression and heating which lead to examine the nuclear consequences, in particular the nucleosynthesis in stellar core. In this article, on the basis of the affine star model of Carter and Luminet, taking into account the variation of entropy, with the use of a new nucleosynthesis code including an optimized reaction network and a relativistic treatment of external gravitational field, we can confirm that the tidal disruption of stars provides really a new site of nucleosynthesis in galactic centers. This study has also pointed out the existence of a new nuclear flow called $\alpha - p$ as well as the possibility of tidal neutronization of a dwarf by a black hole.

By investigating the phenomenon of deep penetration of a star within the tidal radius of a black hole Carter and Luminet (see for example the contribution of J.P. Luminet in these proceedings and references therein) have pointed out the possibility of a new site of nucleosynthesis. When the penetration factor $\beta$ (defined as the ratio between the tidal radius and the periastron distance) is sufficiently high (say $\beta$ greater than 5.) the star undergoes compression to a short lived "pancake" configuration in which the density and temperature rise enough to burn some significant fraction of available nuclear material.

NUCLEOSYNTHESIS DURING PANCAKE PHASE.

Within the framework of the affine star model, the pancake phase can be characterized by
- a high temperature $T_m = \beta^2 T_\star$ (eg $T_\theta > 0.8$)

where $T_\theta$ denotes the temperature in units of $10^9 K$, the subscript $\star$ refering to the initial central stellar value and the subscript $m$ to the maximal central stellar value during the pancake phase.

- a large density $\xi_m = \beta^3 \xi_\star$ (eg $\xi_m > 10^5$ g/cm$^3$)
for a polytropic perfect gas of adiabatic index $\gamma = 5/3$

- a very short timescale $\Delta t_m \propto \rho^{-4} \tau_*$, where $\tau_*$ is the internal timescale of the star given by $\tau_* = (G_{\odot} \rho_*^{1/2})^{-1/2}$.

Such conditions are highly favourable for explosive nucleosynthesis, but such short timescales allow to neglect all weak decays during the pancake phase (but not later of course) and as a consequence there will be no possibility of combustion of hydrogen by pp chains or CNO cycles.

About the nucleosynthetic process, we have, in fact, a helium combustion in a proton rich medium with the following consequences:

- In addition to the triple alpha reaction, the principal reactions are $(\alpha, p)$ followed by $(p, \gamma)$ or $(p, \gamma)$ followed by $(\alpha, p)$ which are, in fact, equivalent to a $(\alpha, \gamma)$ reaction. Hence, only a very few hydrogen will be destroyed (mainly by $^{12}C(p, \gamma)\, ^{13}N(p, \gamma)\, ^{14}O$ or $^{25}Al(p, \gamma)\, ^{26}Si$) during the pancake phase, thus it will still be available as fuel during post-pancake nucleosynthesis (if any).

- Thanks to this two-steps reaction, the rates of the equivalent $-(\alpha, \gamma)$ reactions are strongly enhanced, what is very important when the timescale of the nuclear process is driven by an external dynamical effect.

- For the reasons above, such a process may be called the (explosive) $\alpha$- p process.

For a temperature greater than $T_\theta = 0.8$, the nuclear reaction network is shown in fig. 1.

Figure 1: the nuclear network used for the pancake nucleosynthesis calculation
White circles represent beta-unstable nuclei
Black circles represent stable nuclei.