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A VERY IMPORTANT PROCESS OF NUCLEOSYNTHESIS IN STARS

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ABSTRACT

This is a framework.

At the supernova pre-explosion stage with $M \approx 15\text{--}30M_\odot$, the core with $\bar{\rho} \geq 5*10^{11}$ (g/cm^3), $R \leq 10^7$ cm and $M_1=\frac{4\pi}{3}R^3\bar{\rho} \geq M_\odot$ collapses to a neutron star. The emitted gravitational energy per nucleon $E_n \sim 140$Mev transforms into the radiation energy which prevents material outside $R>10^7$cm from collapsing and causes the explosion of supernova. The γ-radiation is so strong that it makes Fe^{56}--Ni^{60} nuclei of the mass~$0.2M_\odot$ within the inner shell to dissociate and proton-neutron gass with neutron number dencity $n_n \sim 10^{28}\text{--}10^{30}$/cm^3 to be formed. At the same time, the radiation pressure transforms into the kinetic energy of dipersed material, which sets off the shock waves. Thus the local density is $\rho > 10^{12}$ g/cm^3 and neutronization is accelerated, which makes Ca^{56}--Ca^{60} nuclei of $1\text{-}2M_\odot$ mass to collide with each other and to form nuclei with A~112-360. Finally, neutron-rich nuclei (A~140--440, Z~30--82) can be formed by adding a large number of neutrons.

When these nuclei are free from the strong gravitational field, they are unstable and will become stable nuclei by competitions of following processes; (1)neutron-evaporation, (2)spontaneous fission and (3) β^--decay. At the initial stage, (1) and (2) are important and (3) can be ignored.

The qualitative results are as follows;

(1). It seems that nuclei with A>100 come from the spontaneous fission and β^--decay of nutron-evaporated nuclei with A~140--440, which can replace the r-process.

(2). The super-heavy elements with Z=114--126 (A~330--360) can be formed. They can be observed in cosmic rays if they have the halftime $\tau_{\frac{1}{2}} > 10^7$ years.

(3). The peak in the rare-earth elements comes from the symmetric fission of super-heavy elements.

(4). There are more neutron-rich nuclei in the fragments.

(5). The abundances of Z>83 elements in cosmic rays are one order of magnitude higher than that in the solar system.