PROCEEDINGS OF SCIENCE

Rate Analysis or a Possible Interpretation of Abundances

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Heavy elements are formed in nucleosynthesis processes. Abundances of these elements can be classified as elemental abundance, isotopic abundance, and abundance of nuclei. In this work the nuclei are identified by (Z,N), which allows reading out *new information* from the measured abundances. We are interested in the neutron density required to reproduce the measured abundance of nuclei assuming equilibrium processes. This is only possible when two stable nuclei are separated by an unstable nucleus. At these places we investigated the neutron density required for equilibrium nucleosynthesis both isotopically and isotonically at temperatures of AGB interpulse and thermal pulse phases. We obtained an estimate for equilibrium nucleosynthesis neutron density in most of the cases. Next we investigated the possibility of partial formation of nuclei. We analyzed the meaning of the branching factor. We found a mathematical definition for the unified interpretation of a branching point closed at isotonic case and open at isotopic case. We introduce a more expressive variant of branching ratio called partial formation rate. With these we are capable of determining the characteristic neutron density values. We found that all experienced isotope ratios can be obtained both at 10^8 K temperature and at $3\cdot10^8$ K temperature and at intermediate neutron density ($\leq 2\cdot10^{12}$ cm^{-3}).

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1 Speaker

1. Introduction

Nearly sixty years after BBFH [1], it is possible and necessary to review and rethink our knowledge about the neutron capture nucleosynthesis. The result of the formation of the nuclei is shown in the abundances. It is important to mention that the formed unstable nuclei have decayed into stable nuclei and we are only able to see the resulting stable nuclei.

"The success of any theory of nucleosynthesis has to be measured by comparison with the abundance patterns observed in nature." say Käppeler, Beer and Wisshak [2], that is, we need to create such model that gives back the observed abundance.

Because of the formation of nuclei takes place in a variety of conditions, the experienced abundance is a result of more processes. Therefore more models are necessary for the alternate conditions. According to the conditions of the models the nuclei are classified into categories as s-nuclei, r-nuclei etc.

It seems that the reverse approach is also useful: the abundance is the preserver of the nuclei's formation conditions. So instead investigating whether the theoretical model fits the observed abundance, we look for the circumstances when the observed abundance is available.

To do this we need suitable data: the half-life of unstable nuclei and the neutron capture cross section of nuclei. These data are not constant always. At some nuclei the half-lives depend on the temperature [2,3,4]. Fortunately, the reaction rate per particle pair $< \sigma v >$ is constant between 10 and100 keV because of the energy dependence of σ [2,3]. So we can use the σ values at 30 keV [5]. The possible resonances only improve the capture capabilities.

2. The required neutron density

Change the nucleon identification from the usual (Z,A) to (Z,N) and see the individual abundances as well. We took the abundance of nuclei from [6]. This will allow us to read new information from the various measured abundances.

We use the following rate equations according to the requirements of the individual nuclei formation:

$$\frac{dN_{Z,N}}{dt} = N_n(t)N_{Z,N-1}(t) < \sigma v >_{Z,N-1} + \lambda_\beta N_{Z-1,N+1}(t) + \lambda_\alpha N_{Z+2,N+2}(t) - \\ - N_n(t)N_{Z,N}(t) < \sigma v >_{Z,N} - \lambda_\beta N_{Z,N}(t) - \lambda_\alpha N_{Z,N}(t) + \dots$$

We also assume the equilibrium formation of nuclei. From the corresponding rate equations we can get the neutron density as in isotopic as in isotonic cases.

2.1 Isotopic case

2.1.1 Two stable neighbor isotopes

First let us we consider two stable neighbor isotopes (see Fig. 1), applying the new identification.

$$\frac{dN_2}{dt} = n_n N_1 < \sigma v >_1 - n_n N_2 < \sigma v >_2$$

$$\frac{dN_2}{dt} = n_n v(N_1\sigma_1 - N_2\sigma_2)$$

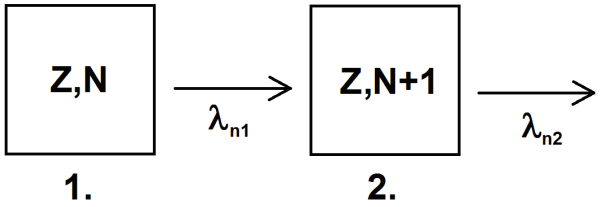

Fig. 1. Two stable neighbor isotopes

If we suppose the equilibrium that is $\frac{dN_2}{dt} = 0$, we got $N_1\sigma_1 = N_2\sigma_2$, what is well known in classical identification. So there is no information about the formation conditions. But it is important to mention that this relation is not true in general about the experienced abundances and neutron capture cross sections. The main cause is the existences of other rates from other channels through unstable nuclei.

2.1.2 Two stable isotopes are separated by an unstable isotope

A more interesting case is, when two stable isotopes are separated by an unstable isotope (see Fig. 2).

In this isotopic case the rate equations for the unstable nucleus:

$$\frac{dN_2}{dt} = n_n N_1 < \sigma v >_1 - n_n N_2 < \sigma v >_2 - \lambda_\beta N_2$$

About the equilibrium $\frac{dN_2}{dt} = 0$, so

$$0 = n_n(N_1 < \sigma v >_1 - N_2 < \sigma v >_2) - \lambda_\beta N_2$$

$$\lambda_\beta N_2 = n_n(N_1 < \sigma v >_1 - N_2 < \sigma v >_2)$$

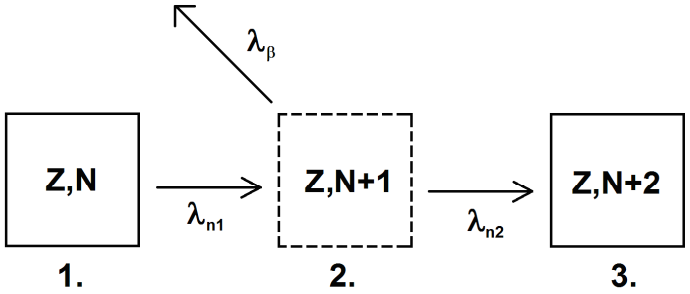

Fig. 2. The isotopic channel

$$\lambda_\beta N_2 = n_n v(N_1\sigma_1 - N_2\sigma_2)$$

$$\lambda_\beta = n_n v(\frac{N_1}{N_2}\sigma_1 - \sigma_2)$$

If the third nucleus can form only from the second nucleus

$$\frac{dN_3}{dt} = n_n N_2 < \sigma v >_2 - n_n N_3 < \sigma v >_3$$

About the equilibrium $\frac{dN_3}{dt} = 0$, so such as the previous case we have

$$N_2\sigma_2 = N_3\sigma_3$$

$$N_2 = N_3\frac{\sigma_3}{\sigma_2}$$

$$\lambda_\beta = n_n v(\sigma_1\frac{N_1\sigma_2}{N_3\sigma_3} - \sigma_2)$$

$$\frac{\lambda_\beta}{n_n v} + \sigma_2 = \frac{N_1\sigma_1\sigma_2}{N_3\sigma_3}$$

$$\frac{N_3}{N_1} = \frac{\sigma_1\sigma_2}{(\frac{\lambda_\beta}{n_n v} + \sigma_2)\sigma_3}$$

$$\frac{N_3}{N_1} = \frac{< \sigma v >_1}{< \sigma v_3 >}\frac{< \sigma v >_2}{\frac{\lambda_\beta}{n_n} + < \sigma v >_2} = \frac{\sigma_1}{\sigma_3}\frac{\sigma_2}{\frac{\lambda_\beta}{n_n v} + \sigma_2}$$

This expression contains the specific neutron density value. We must refer to $< \sigma v > = \sigma \cdot v = \text{constant}$ at low and intermediat conditions, so it is enough to know the 30 keV neutron capture cross sections and average velocity.
From this formula, we can get the neutron density value. Of coure resonances may occure, but these only improve the capture capabilities

$$n_n = \frac{\lambda_\beta}{v(\sigma_1\frac{N_1\sigma_2}{N_3\sigma_3} - \sigma_2)} \text{ or } n_n = \frac{\lambda_\beta}{v}\frac{\sigma_3}{\sigma_2}\frac{1}{(\sigma_1\frac{N_1}{N_3} - \sigma_3)}$$

(See the required neutron densities at different stellar temperature in Appendix 1 and 2.)
From the tables we can see that the isotopic equilibrium is not always possible. This means that the formation of third nuclei has at least another channel.

2.2 Isotonic case

In this isotopic case (see Fig. 3) the rate equations for the unstable nucleus:

$$\frac{dN_2}{dt} = n_n N_1 < \sigma v >_1 - n_n N_2 < \sigma v >_2 - \lambda_\beta N_2$$

If there is equilibrium, then $\frac{dN_2}{dt} = 0$, so

$$n_n N_1 < \sigma v_1 >= n_n < \sigma v >_2 N_2 + \lambda_\beta N_2$$

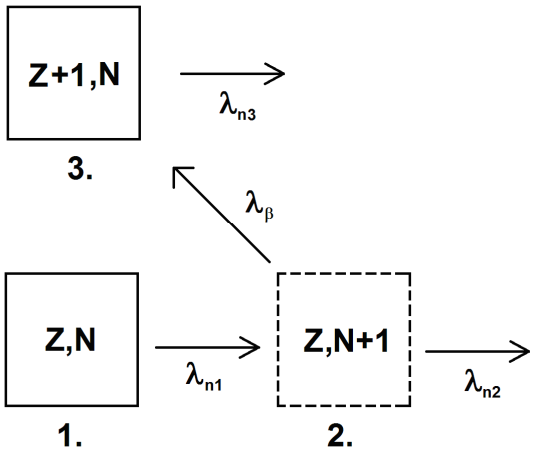

Fig. 3. The isotonic channel

If the third nucleus can form only from second nucleus

$$\frac{dN_3}{dt} = \lambda_\beta N_2 - n_n N_3 < \sigma v >_3$$

Beacause of the equilibrium $\frac{dN_3}{dt} = 0$ we get

$$\lambda_\beta N_2 = n_n N_3 < \sigma v >_3$$

The two equations

$$n_n N_1 < \sigma v_1 >= n_n N_2 < \sigma v >_2 + \lambda_\beta N_2$$
$$\lambda_\beta N_2 = n_n N_3 < \sigma v >_3$$

about these

$$\frac{N_1}{N_3}\frac{< \sigma v >_1}{< \sigma v >_3} = \frac{n_n < \sigma v >_2 + \lambda_\beta}{\lambda_\beta}$$
$$\frac{N_1}{N_3}\frac{< \sigma v >_1}{< \sigma v >_3}\lambda_\beta - \lambda_\beta = n_n < \sigma v >_2$$

From this formula, we can get the neutron density value for equilibrium nucleosynthesis.

$$n_n = \frac{\frac{N_1}{N_3}\frac{< \sigma v >_1}{< \sigma v >_3}\lambda_\beta - \lambda_\beta}{< \sigma v >_2} \text{ or } n_n = \frac{\frac{N_1}{N_3}\frac{\sigma_1}{\sigma_3} - 1}{\sigma_2}\frac{\lambda_\beta}{v}$$

Because of $< \sigma v > = \sigma \cdot v = \text{constant}$ it is enough to take the neutron capture values at 30keV.

(See the required neutron densities at different stellar temperature in Appendix 3 and 4.)

2.3 The role of neutron density

We have the possible equilibrium neutron density at isotopic and isotonic cases as well. There is a big difference between the two cases. In isotopic case the increment of neutron density increases the amount of the third nuclei, but in isotonic case the increment of neutron

density decreases the amount of the third nuclei. These result the shift of capture path (or capture band) toward neutron rich nuclei.

3. Partial formation of nuclei

We can see in the previous section that not all of the third nuclei can form from the first nuclei. But how much can be formed on this way?

Suppose that from the abundance of the first nuclei (N_1) the k-times the abundance of third nuclei ($k \cdot N_3$) are formed ($0 < k$). What neutron density is required in this case? (Here k is the Partial Formation Ratio so PFR.) If $k = 1$ then all of the third nuclei are formed as in the previous section 3.

The required neutron density at the two channels in isotopic and in isotonic cases:

$$n_n = \frac{\lambda_\beta}{v}\frac{\sigma_3}{\sigma_2}\frac{1}{\left(\frac{N_1\sigma_1}{kN_3} - \sigma_3\right)} \qquad n_n = \frac{\lambda_\beta}{v\sigma_2}\left(\frac{N_1}{N_3}\frac{\sigma_1}{\sigma_3}\frac{1}{k} - 1\right)$$

4. Given neutron density

After this theoretic investigation it is necessary to take a realistic approach.

We can consider the inverse question: what part of third nuclei abundance is formed from the first nuclei abundance at given neutron density? ($k = ?$)

4.1 In isotopic case:

$$k_Z = R\frac{\lambda_n}{(\lambda_n + \lambda_\beta)} = \frac{N_1\sigma_1}{N_3\sigma_3}\frac{\lambda_n}{(\lambda_n + \lambda_\beta)} = \frac{N_1\sigma_1}{N_3\sigma_3}\frac{\frac{\lambda_n}{\lambda_\beta}}{\left(\frac{\lambda_n}{\lambda_\beta} + 1\right)}$$

$$g(x)_Z = R\frac{x}{(x+1)} = \frac{N_1\sigma_1}{N_3\sigma_3}\frac{x}{(x+1)} = R \cdot f_n(x) \qquad x = \frac{\lambda_n}{\lambda_\beta}$$

4.2 In isotonic case:

$$k_N = R\frac{\lambda_\beta}{(\lambda_n + \lambda_\beta)} = \frac{N_1\sigma_1}{N_3\sigma_3}\frac{\lambda_\beta}{(\lambda_n + \lambda_\beta)} = \frac{N_1\sigma_1}{N_3\sigma_3}\frac{1}{\left(\frac{\lambda_n}{\lambda_\beta} + 1\right)}$$

$$g(x)_N = R\frac{1}{(x+1)} = \frac{N_1\sigma_1}{N_3\sigma_3}\frac{1}{(x+1)} = R \cdot f_\beta(x) \qquad x = \frac{\lambda_n}{\lambda_\beta}$$

Where f_n and f_β are the classical branching factors for neutron capture and beta decay. So we have uniform functions in both isotopic and isotonic cases.

5. Mathematical analysis

It might be better to see these functions in logarithmic representation.

On Fig. 4 the two branching functions are: $f_n(x)$ and $f_\beta(x)$, where $\xi = \lg x$:

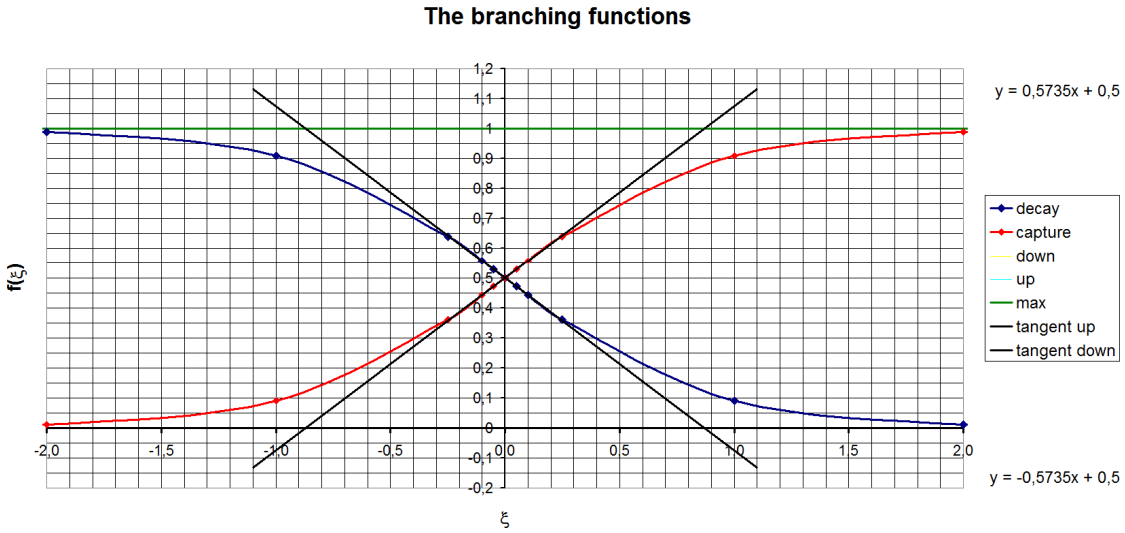

Fig. 4. The two branching functions in logharitmic scale

In this logarithmic representation the two functions become symmetric. Then we take the two logarithmic tangents at $\xi = 0$ or $x = 1$.

Where these tangents take the value zero the isotopic formation of nuclei opens, and the isotonic formation of nuclei closes. Similarly, where the tangent takes value one, the isotopic formation is on and the isotonic formation is off. So we have got well-defined characteristics for both of the opening and closing cases.

We found a mathematical definition for the unified interpretation of a branching point closed at the isotonic case and open at the isotopic case.

6. The neutron density range

From the mathematical analysis we get the next values:

Tab. 1.

ξ	x	branching ratio		channel	
		f_n	f_β	isotopic	isotonic
-0.872	0,135	0.119	0.881	opening	closing
0,872	7,398	0.881	0.119	opened	closed

The isotopic channel is beginning to open and isotonic channel is beginning to close when $\lambda_n \approx 0{,}135 \cdot \lambda_\beta$. Isotonic channel is nearly closed and isotopic channel is almost fully opened when $\lambda_n \approx 7{,}39 \cdot \lambda_\beta$ .We have reviewed the appropriate three nuclei cases and examined both of T_8 and $3T_8$ cases.

At these cases we have got the maximum of all neutron density not more than $n_n = 10^{14}\,cm^{-3}$. Some details are shown on the Fig. 5. Upper lines refer to isotonic cases; the bottom lines refer to isotopic cases. The temperature dependence of half-lives we took from [4].

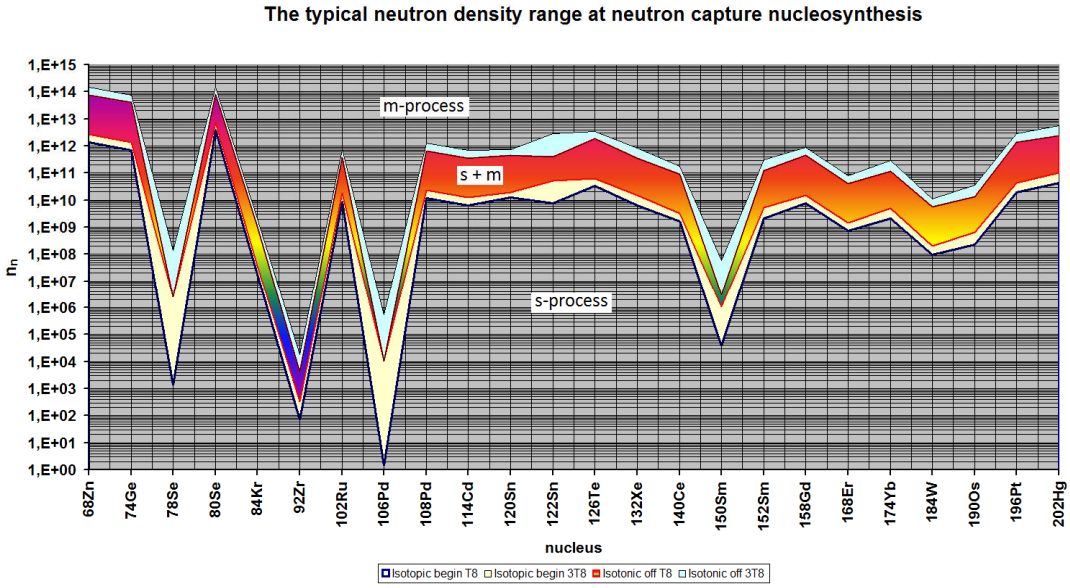

Fig. 5. The range of neutron capture nucleosynthesis about neutron density.

All nuclei formation is available at a neutron density range between s-process and r-process. This process is m-process (i-process) (medium or interMediate) [7,8,9,10,11].

7. Branching in a new point of view

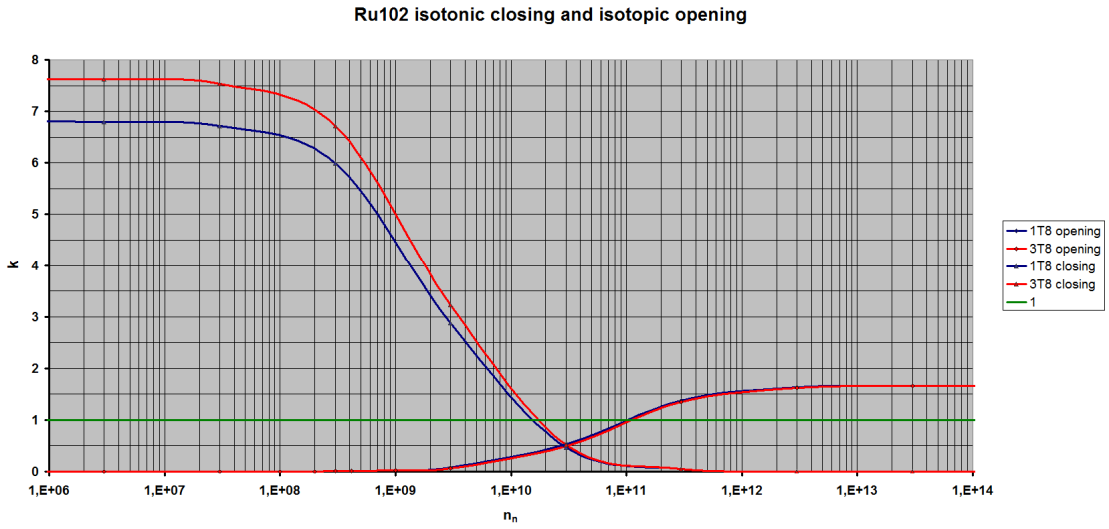

Fig. 6. Partial formation ratio from ^{102}Ru as the function of neutron density. Here we can the temperature dependence of the formation ratio as well. At ^{102}Ru there is no isomer.

The branching factor does not give the correct formation ratio. It gives the partial formation ratio: $k = R \cdot f$. (Data from KADoNiS [12], NNDC [13].) The k is determined by f

and R, where $R = \frac{N_1\sigma_1}{N_3\sigma_3}$. The PFR is changing the amount of formed nuclei. The graph on Fig. 6 shows the k as a function of neutron density in the cases of $^{102}\mathrm{Ru} \rightarrow ^{103}\mathrm{Rh}$ and $^{102}\mathrm{Ru} \rightarrow ^{104}\mathrm{Ru}$ as well. These are both simple cases with only one incoming channel.

8. Full network model

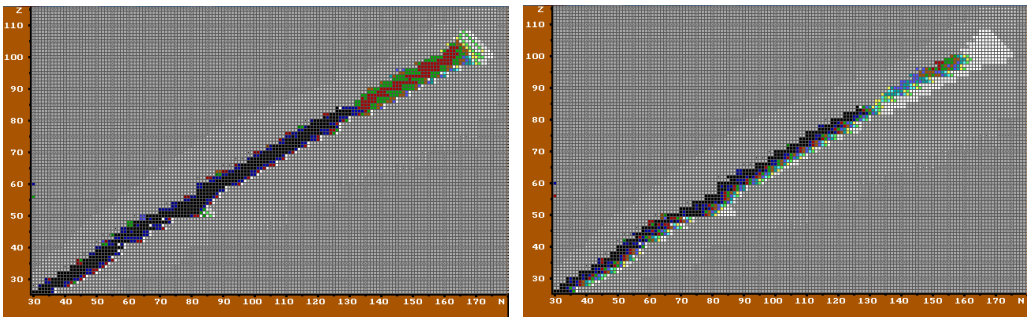

Fig. 7. The band of neutroncapture nucleosynthesis at AGP TP phase and at IP after TP

We can see in one unified model the entire possible neutron capture and decay processes [11,14]. Here we can change the neutron density and other parameters. But more data is required here [5]. The formation of nuclei rather occurs along a band than along a path (see Fig. 7). The neutron capture band is only visible in logarithmic representation. The structure of band at $Z = 50$, at tin isotopes is visible on Fig. 8.

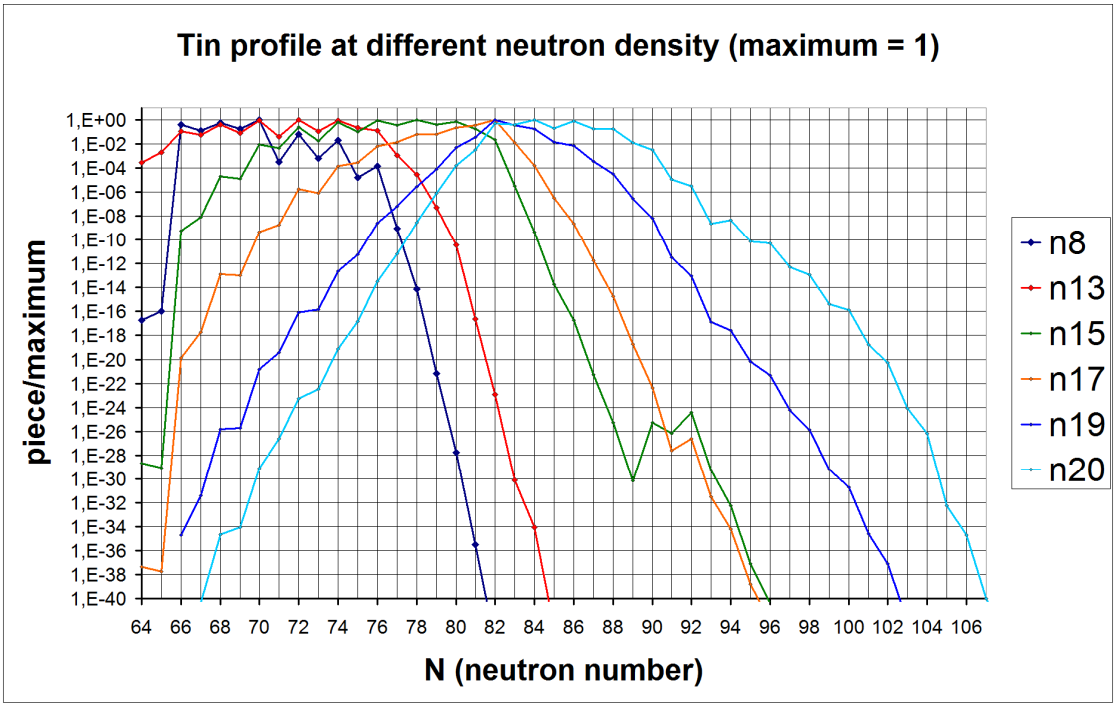

Fig. 8. The profil of neutron capture band at tin isotopes. ($n8 = 10^8 \mathrm{cm}^{-3}$)

9. What does path mean at arbitrary neutron density?

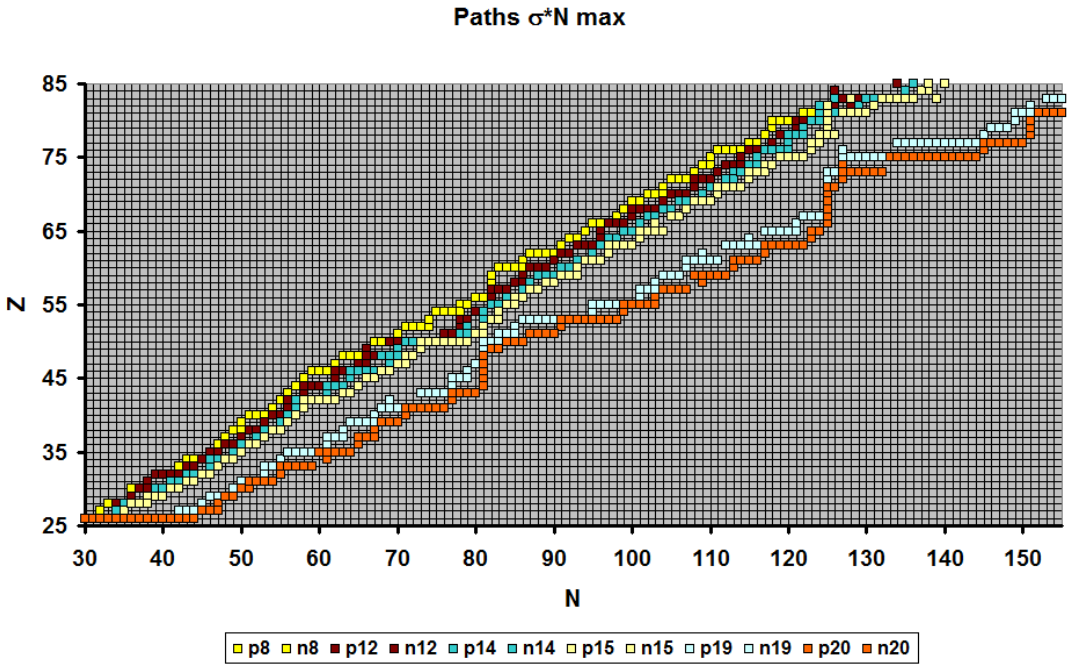

Fig. 9. The different paths at different neutron density. The maximum values we took from isotonically (p) or isotopically (n). Here p8 and n8 refer to the $\mathrm{n8} = 10^{8}\,\mathrm{cm}^{-3}$ *neutron density.*

Instead of the classical paths the paths are more like the ridge of the σN value at given neutron density, in case of the neutron capture nucleosynthesis. There is s-path, r-path and between them are the m-paths on the Fig. 9 at different neutron density by the unified model [14]. The s-path is the theoretical edge of the paths at very low neutron density.

10. Experimental constraints: tellurium and technetium and iron

The isotope anomalies at tellurium [11] and xenon [15] or the presence or absence of the technetium in AGB stars [16,17] can be explained with m-process. These depend on where the „path" is. We have found that the two "r-only" isotopes of tellurium ($^{128}\mathrm{Te}$, $^{130}\mathrm{Te}$) are formed mainly in the m-process at AGB conditions [11].

The existence of $^{60}\mathrm{Fe}$ radioisotope is also important. The stable $^{58}\mathrm{Fe}$ is separated from $^{60}\mathrm{Fe}$ by the unstable isotope $^{59}\mathrm{Fe}$. The case is the same on the Fig. 2. The third nuclei are $^{60}\mathrm{Fe}$. The rate equation for the $^{59}\mathrm{Fe}$:

$$\frac{dN_2}{dt} = n_n N_1 < \sigma v >_1 - n_n N_2 < \sigma v >_2 - \lambda_{\beta 2} N_2$$

$$\frac{dN_3}{dt} = n_n N_2 < \sigma v >_2 - n_n N_3 < \sigma v >_3 - \lambda_{\beta 3} N_3$$

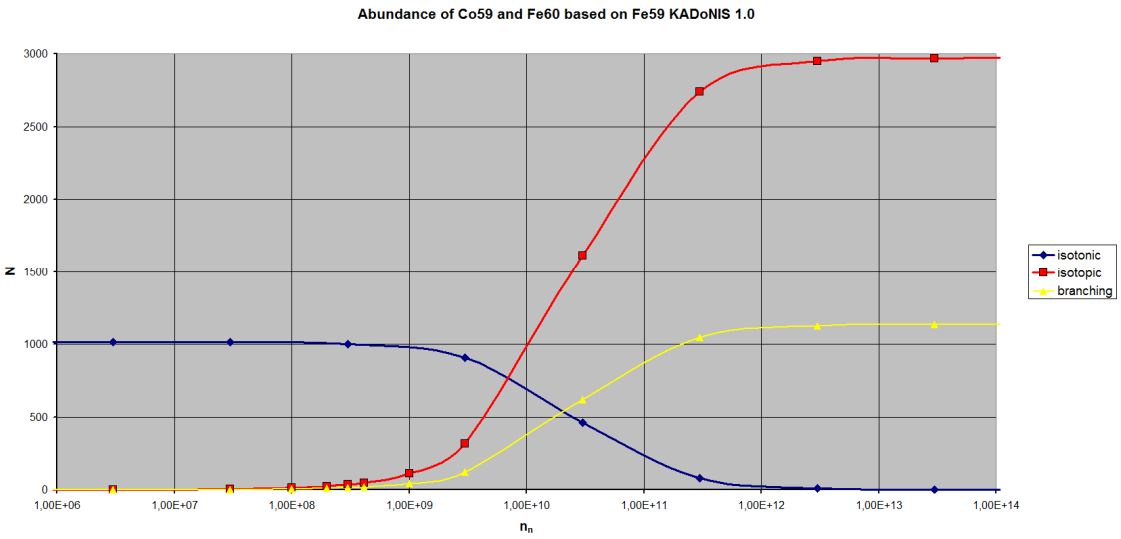

Fig. 10. The $^{59}\mathrm{Co}$ *and* $^{60}\mathrm{Fe}$ *abundance at different neutrondensity. The figure shows the difference beetven PFR and the branchig factor*

In the case of equilibrium comes:

$$N_3 = \frac{N_1\sigma_1}{\sigma_3 + \frac{\lambda_{\beta 3}}{n_n v}} \frac{\lambda_{n2}}{\lambda_{n2} + \lambda_{\beta 2}} = \frac{N_1\sigma_1}{\sigma_3 + \frac{\lambda_{\beta 3}}{n_n v}} f_{n2} \qquad N_3 = \frac{N_1\sigma_1}{\sigma_3 + \frac{\lambda_{\beta 3}}{n_n v}} \frac{x_2}{1+x_2}$$

Because of the half-life of $^{60}\mathrm{Fe}$ $(T = 1{,}5 \cdot 10^6\,\mathrm{y})$ $\frac{\lambda_{\beta 3}}{n_n v} << \sigma_3$, so it is negligible [18,19].

$$N_3 = \frac{N_1\sigma_1}{\sigma_3 + \frac{\lambda_{\beta 3}}{n_n v}} \frac{x_2}{1+x_2} \cong \frac{N_1\sigma_1}{\sigma_3} \frac{x_2}{1+x_2} = \frac{N_1\sigma_1}{\sigma_3} f_{n2} = N_1 \frac{\sigma_1}{\sigma_3} f_{n2} = N_1 \frac{13{,}5}{5{,}15} f_{n2} = N_1 \cdot 2{,}62 \cdot f_{n2}$$

At a given neutron density the amount of $^{60}\mathrm{Fe}$ is nearly three times what we get from the simple branching ratio (see Fig. 10). We used data from KADoNiS 1.0 [19].

This explains the high abundance of $^{60}\mathrm{Ni}$, which is four times (4.34 times) the amount of $^{59}\mathrm{Co}$. The formation of $^{60}\mathrm{Ni}$ nuclei occurs mainly through the $^{60}\mathrm{Fe}$ channel.

11. Conclusion

All experienced isotope ratios can be obtained both at $10^8\,\mathrm{K}$ temperature and at $3 \cdot 10^8\,\mathrm{K}$ temperature at intermediate neutron density (10^{12}-$10^{14}\,\mathrm{cm}^{-3}$), so the m-process and the AGB stars are probably one of the main places of nucleosynthesis. It seems that the so-called r-nuclei can form in intermediate processes as well.

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Appendix

1. Isotopic equilibrium neutron density at a temperature of 10^8 K

	nuc_1	log y_1 (Si=6)	σ_1 (mb)	nuc_2	T_2	time unit	σ_2 (mb)	nuc_3	σ_3 (mb)	log y_3 (Si=6)	n_n (cm^{-3})	lg n_n
1.	62Ni	3,255	**22,2**	63Ni	100,1	Y	**66,7**	64Ni	**8,4**	2,726	2,2E+06	6,33
2.	68Zn	2,369	**20,7**	69Zn	56,4	m	75,4	70Zn	***10,9***	0,893	1,8E+11	11,25
3.	68Zn	2,369	**20,7**	$69Zn^m$	13,76	d*	*110,9*	70Zn	***10,9***	0,893	3,5E+08	8,54
4.	69Ga	1,358	**118,7**	70Ga	21,14	d	301,5	71Ga	***104,6***	1,176	6,4E+09	9,81
5.	74Ge	1,638	**37,6**	75Ge	82,78	m	*203,2*	*76Ge*	**24,4**	0,965	4,0E+11	11,61
6.	78Se	1,164	**61,1**	79Se	2,95E+05	y	***263***	80Se	**38**	1,49	-4,3E+04	n/a
7.	80Se	1,49	**38**	81Se	18,45	m	82,3	*82Se*	**8,4**	0,757	1,2E+12	12,08
8.	80Se	1,49	**38**	$81Se^m$	57,28	m*	82,3	*82Se*	**8,4**	0,757	3,8E+11	11,59
9.	79Br	0,775	**622**	80Br	1,77E+01	m	790,0	81Br	**239**	0,766	1,8E+12	12,25
10.	79Br	0,775	**622**	$80Br^m$	4,42E+00	h*	790,0	81Br	**239**	0,766	1,2E+11	11,08
11.	84Kr	1,408	**32,6**	85Kr	3916,8	D	**73**	86Kr	**4,76**	0,893	4,8E+06	6,68
12.	84Kr	1,408	**32,6**	$85Kr^m$	4,48	h 78,6%	**73**	86Kr	**4,76**	0,893	1,0E+11	11,01
13.	85Rb	0,709	**234**	86Rb	18,642	d	***202***	87Rb	**15,7**	0,316	2,2E+08	8,34
14.	92Zr	0,209	**37,8**	93Zr	1,53E+06	Y	**96**	*94Zr*	**27,3**	0,209	1,3E+03	3,12
15.	94Zr	0,297	**27,3**	95Zr	64,032	D	***79***	*96Zr*	**10,3**	-0,496	3,8E+08	8,58
16.	98Mo	-0,218	**70,5**	99Mo	2,7489	D	***240***	*100Mo*	**80,5**	-0,609	3,9E+10	10,59
17.	102Ru	-0,231	**151**	103Ru	29,26	D	***343***	*104Ru*	**154**	-0,461	9,5E+10	10,98
18.	106Pd	-0,42	**244**	107Pd	6,50E+06	Y	**1302**	108Pd	**218**	-0,431	7,4E+01	1,87
19.	108Pd	-0,431	**218**	109Pd	13,70012	H	*236,3*	*110Pd*	**157**	-0,785	1,0E+11	11,01
20.	107Ag	-0,602	**787**	108Ag	2,37	m	1788,0	109Ag	**793**	-0,627	2,0E+14	14,29
21.	107Ag	-0,602	**787**	$108Ag^m$	438	y*ec	*1383,0*	109Ag	**793**	-0,627	2,6E+06	6,42
22.	114Cd	-0,333	**135,3**	115Cd	53,46	H	***290***	*116Cd*	**76,1**	-0,914	7,9E+09	9,90
23.	114Cd	-0,333	**135,3**	$115Cd^m$	44,56	d	224	*116Cd*	**76,1**	-0,914	5,1E+08	8,71
24.	113In	-2,103	**809**	114In	71,9	s	1308,0	115In	**776**	-0,754	-2,8E+13	n/a
25.	113In	-2,103	**809**	$114In^m$	49,51	d*	2595	115In	**776**	-0,754	-2,4E+08	n/a
26.	120Sn	0,097	**36,3**	121Sn	27,03	H	167	*122Sn*	**22,6**	-0,745	9,1E+09	9,96
27.	120Sn	0,097	**36,3**	$121Sn^m$	43,9	y 22%	*175,4*	*122Sn*	**22,6**	-0,745	6,1E+05	5,79
28.	122Sn	-0,745	**22,6**	123Sn	129,2	D	361	*124Sn*	**15,7**	-0,644	3,9E+11	11,59
29.	122Sn	-0,745	**22,6**	$123Sn^m$	40,06	m	361	*124Sn*	**15,7**	-0,644	1,8E+15	15,26
30.	121Sb	-0,752	**532**	122Sb	**3**	**D**	894	123Sb	**303**	-0,879	9,0E+09	9,95
31.	126Te	-0,046	**81,3**	127Te	9,35	H	*256,8*	*128Te*	**44,4**	0,185	3,9E+12	12,59
32.	126Te	-0,046	**81,3**	$127Te^m$	109	d 2,4%	*668,6*	*128Te*	**44,4**	0,185	1,1E+11	11,05
33.	128Te	0,185	**44,4**	129Te	69,6	M	137,5	*130Te*	**14,2**	0,22	2,4E+12	12,37

	nuc_1	log y_1 (Si=6)	σ_1 (mb)	nuc_2	T_2	time unit	σ_2 (mb)	nuc_3	σ_3 (mb)	log y_3 (Si=6)	n_n (cm^{-3})	lg n_n
34.	128Te	0,185	**44,4**	$129Te^m$	33,6	d*	*493,6*	*130Te*	**14,2**	0,22	9,5E+08	8,98
35.	132Xe	0,086	**63,8**	133Xe	5,243	D	127	*134Xe*	**21,3**	-0,321	7,2E+09	9,86
36.	134Xe	-0,321	**21,3**	135Xe	9,14	H	65,6	*136Xe*	**0,98**	-0,405	4,7E+10	10,67
37.	140Ce	0,004	**11,73**	141Ce	32,508	D	*76*	*142Ce*	**29,9**	-0,9	5,6E+09	9,75
38.	146Nd	-0,845	**91,2**	147Nd	10,98	D	544	*148Nd*	**146,6**	-1,324	5,7E+09	9,75
39.	148Nd	-1,324	**146,6**	149Nd	17,28	H	*513,2*	*150Nd*	**156,1**	-1,333	-1,9E+12	n/a
40.	150Sm	-1,717	**422,3**	151Sm	90	Y	**3040**	*152Sm*	**464,8**	-1,161	-3,7E+05	n/a
41.	152Sm	-1,161	**464,8**	153Sm	46,284	H	*1095*	*154Sm*	**216,9**	-1,232	1,0E+10	10,01
42.	158Gd	-1,086	**323,6**	159Gd	18,479	H	*455,2*	*160Gd*	**178**	-1,141	7,6E+10	10,88
43.	168Er	-1,168	**319**	169Er	9,392	D	653,0	*170Er*	**170,2**	-1,428	2,2E+09	9,35
44.	174Yb	-1,103	**150,5**	175Yb	4,185	D	558	*176Yb*	**115,9**	-1,5	6,7E+09	9,83
45.	184W	-1,389	**225**	185W	75,1	D	**633**	*186W*	**226**	-1,423	8,8E+09	9,94
46.	185Re	-1,717	**1438,5**	186Re	3,7186	D	**743**	187Re	**1184**	-1,475	-3,5E+10	n/a
47.	185Re	-1,717	**1438,5**	$186Re^m$	2,00E+05	y*	**743**	187Re	**1184**	-1,475	-1,8E+03	n/a
48.	190Os	-0,75	**278**	191Os	15,4	D	*1290*	*192Os*	**160**	-0,558	1,4E+10	10,16
49.	191Ir	-0,607	**1350**	192Ir	73,827	D	*2080*	193Ir	**994**	-0,383	-1,0E+09	n/a
50.	191Ir	-0,607	**1350**	$192Ir^m$	241	y*ec	*2080*	193Ir	**994**	-0,383	-8,6E+05	n/a
51.	196Pt	-0,47	**167,4**	197Pt	19,8915	H	*79,7*	*198Pt*	**94**	-1,015	8,6E+10	10,93
52.	202Hg	-0,996	**63,3**	203Hg	46,594	D	*98*	*204Hg*	**42**	-1,633	5,7E+10	10,76
53.	203Tl	-1,265	**170,5**	204Tl	3,78	y	215	205Tl	**53**	-0,866	3,4E+08	8,53

2. Isotopic equilibrium neutron density at a temperature of $3 \cdot 10^8 \mathrm{K}$

	nuc_1	log y_1 (Si=6)	σ_1 (mb)	nuc_2	T_2	time unit	σ_2 (mb)	nuc_3	σ_3 (mb)	log y_3 (Si=6)	n_n (cm^{-3})	lg n_n
1.	62Ni	3,255	**22,2**	63Ni	100,1	Y	**66,7**	64Ni	**8,4**	2,726	1,2E+07	7,09
2.	68Zn	2,369	**20,7**	69Zn	56,4	m	75,4	70Zn	**10,9**	0,893	1,8E+11	11,25
3.	68Zn	2,369	**20,7**	$69Zn^m$	13,76	d*	*110,9*	70Zn	**10,9**	0,893	3,5E+08	8,54
4.	69Ga	1,358	**118,7**	70Ga	21,14	d	301,5	71Ga	**104,6**	1,176	6,4E+09	9,81
5.	74Ge	1,638	**37,6**	75Ge	82,78	m	*203,2*	*76Ge*	**24,4**	0,965	4,0E+11	11,60
6.	78Se	1,164	**61,1**	79Se	2,95E+05	y	263	80Se	**38**	1,49	-7,6E+07	n/a
7.	80Se	1,49	**38**	81Se	18,45	m	82,3	*82Se*	**8,4**	0,757	1,1E+12	12,05
8.	80Se	1,49	**38**	$81Se^m$	57,28	m*	82,3	*82Se*	**8,4**	0,757	3,6E+11	11,55
9.	79Br	0,775	**622**	80Br	1,77E+01	m	790,0	81Br	**239**	0,766	1,2E+12	12,08
10.	79Br	0,775	**622**	$80Br^m$	4,42E+00	h*	790,0	81Br	**239**	0,766	7,9E+10	10,90
11.	84Kr	1,408	**32,6**	85Kr	3916,8	D	**73**	86Kr	**4,76**	0,893	4,9E+06	6,69

	nuc_1	**log y_1 (Si=6)**	**σ_1 (mb)**	**nuc_2**	**T_2**	**time unit**	**σ_2 (mb)**	**nuc_3**	**σ_3 (mb)**	**log y_3 (Si=6)**	**n_n (cm^{-3})**	**lg n_n**
12.	84Kr	1,408	**32,6**	$85Kr^m$	4,48	h 78,6%	**73**	86Kr	**4,76**	0,893	1,0E+11	11,02
13.	85Rb	0,709	**234**	86Rb	18,642	d	202	87Rb	**15,7**	0,316	2,3E+11	11,36
14.	92Zr	0,209	**37,8**	93Zr	1,53E+06	Y	**96**	*94Zr*	**27,3**	0,209	4,8E+03	3,68
15.	94Zr	0,297	**27,3**	95Zr	64,032	D	79	*96Zr*	**10,3**	-0,496	3,8E+08	8,58
16.	98Mo	-0,218	**70,5**	99Mo	2,7489	D	240	*100Mo*	**80,5**	-0,609	5,8E+10	10,76
17.	102Ru	-0,231	**151**	103Ru	29,26	D	343	*104Ru*	**154**	-0,461	1,1E+11	11,03
18.	106Pd	-0,42	**244**	107Pd	6,50E+06	Y	**1302**	108Pd	**218**	-0,431	5,2E+05	5,72
19.	108Pd	-0,431	**218**	109Pd	13,70012	H	*236,3*	*110Pd*	**157**	-0,785	1,0E+11	11,01
20.	107Ag	-0,602	**787**	108Ag	2,37	m	1788,0	109Ag	**793**	-0,627	1,7E+14	14,23
21.	107Ag	-0,602	**787**	$108Ag^m$	438	y*ec	*1383,0*	109Ag	**793**	-0,627	2,3E+06	6,36
22.	114Cd	-0,333	**135,3**	115Cd	53,46	H	290	*116Cd*	**76,1**	-0,914	7,9E+09	9,90
23.	114Cd	-0,333	**135,3**	$115Cd^m$	44,56	d	224	*116Cd*	**76,1**	-0,914	5,1E+08	8,71
24.	113In	-2,103	**809**	114In	71,9	s	1308,0	115In	**776**	-0,754	-2,8E+13	n/a
25.	113In	-2,103	**809**	$114In^m$	49,51	d*	2595	115In	**776**	-0,754	-2,4E+08	n/a
26.	120Sn	0,097	**36,3**	121Sn	27,03	H	167	*122Sn*	**22,6**	-0,745	4,6E+09	9,66
27.	120Sn	0,097	**36,3**	$121Sn^m$	43,9	y 22%	*175,4*	*122Sn*	**22,6**	-0,745	3,0E+05	5,48
28.	122Sn	-0,745	**22,6**	123Sn	129,2	D	361	*124Sn*	**15,7**	-0,644	2,4E+12	12,38
29.	122Sn	-0,745	**22,6**	$123Sn^m$	40,06	m	361	*124Sn*	**15,7**	-0,644	1,1E+16	16,04
30.	121Sb	-0,752	**532**	122Sb	**3**	D	894	123Sb	**303**	-0,879	3,4E+10	10,53
31.	126Te	-0,046	**81,3**	127Te	9,35	H	*256,8*	*128Te*	**44,4**	0,185	3,4E+12	12,53
32.	126Te	-0,046	**81,3**	$127Te^m$	109	d 2,4%	*668,6*	*128Te*	**44,4**	0,185	9,6E+10	10,98
33.	128Te	0,185	**44,4**	129Te	69,6	M	137,5	*130Te*	**14,2**	0,22	2,2E+12	12,35
34.	128Te	0,185	**44,4**	$129Te^m$	33,6	d*	*493,6*	*130Te*	**14,2**	0,22	9,0E+08	8,95
35.	132Xe	0,086	**63,8**	133Xe	5,243	D	127	*134Xe*	**21,3**	-0,321	9,4E+09	9,97
36.	134Xe	-0,321	**21,3**	135Xe	9,14	H	65,6	*136Xe*	**0,98**	-0,405	4,7E+10	10,67
37.	140Ce	0,004	**11,73**	141Ce	32,508	D	76	*142Ce*	**29,9**	-0,9	5,6E+09	9,75
38.	146Nd	-0,845	**91,2**	147Nd	10,98	D	544	*148Nd*	**146,6**	-1,324	5,7E+09	9,75
39.	148Nd	-1,324	**146,6**	149Nd	17,28	H	*513,2*	*150Nd*	**156,1**	-1,333	-1,9E+12	n/a
40.	150Sm	-1,717	**422,3**	151Sm	90	Y	**3040**	*152Sm*	**464,8**	-1,161	-9,8E+06	n/a
41.	152Sm	-1,161	**464,8**	153Sm	46,284	H	1095	*154Sm*	**216,9**	-1,232	1,6E+10	10,20
42.	158Gd	-1,086	**323,6**	159Gd	18,479	H	*455,2*	*160Gd*	**178**	-1,141	7,6E+10	10,88
43.	168Er	-1,168	**319**	169Er	9,392	D	653,0	*170Er*	**170,2**	-1,428	2,2E+09	9,33
44.	174Yb	-1,103	**150,5**	175Yb	4,185	D	558	*176Yb*	**115,9**	-1,5	1,0E+10	10,00
45.	184W	-1,389	**225**	185W	75,1	D	**633**	*186W*	**226**	-1,423	9,5E+09	9,98
46.	185Re	-1,717	**1438,5**	186Re	3,7186	D	**743**	187Re	**1184**	-1,475	-3,8E+10	n/a
47.	185Re	-1,717	**1438,5**	$186Re^m$	2,00E+05	y*ec	**743**	187Re	**1184**	-1,475	-1,9E+03	n/a
48.	190Os	-0,75	**278**	191Os	15,4	D	1290	*192Os*	**160**	-0,558	2,6E+10	10,41

	nuc_1	$\log y_1$ (Si=6)	σ_1 (mb)	nuc_2	T_2	time unit	σ_2 (mb)	nuc_3	σ_3 (mb)	$\log y_3$ (Si=6)	n_n (cm^{-3})	lg n_n
49.	191Ir	-0,607	**1350**	192Ir	73,827	D	2080	193Ir	**994**	-0,383	-1,4E+09	n/a
50.	191Ir	-0,607	**1350**	$192Ir^m$	2,41E+02	y*	2080	193Ir	**994**	-0,383	-1,2E+06	n/a
51.	196Pt	-0,47	**167,4**	197Pt	19,8915	H	*79,7*	*198Pt*	**94**	-1,015	9,9E+10	11,00
52.	202Hg	-0,996	**63,3**	203Hg	46,594	D	98	*204Hg*	**42**	-1,633	8,1E+10	10,91
53.	203Tl	-1,265	**170,5**	204Tl	3,78	y	215	205Tl	**53**	-0,866	6,8E+10	10,83

3. Isotonic equilibrium neutron density at a temperature of 10^8K

	nuc_1	$\log y_1$ (Si=6)	σ_1 (mb)	nuc_2	T_2	time unit	σ_2 (mb)	nuc_3	σ_3 (mb)	$\log y_3$ (Si=6)	n_n (cm^{-3})	lg n_n
1.	58Fe	3,473	**13,3**	44,4495	d	59Fe	**26,4**	59Co	**40,1**	3,352	-1,4E+10	n/a
2.	59Co	3,352	**40,1**	1925,28	d	60Co	*12,64*	60Ni	**29,9**	4,11	-1,2E+09	n/a
3.	62Ni	3,255	**22,2**	100,1	y	63Ni	**66,7**	63Cu	**53,7**	2,558	1,8E+07	7,26
4.	*64Ni*	*2,726*	**8**	*2,5172*	*h*	*65Ni*	21,2	*65Cu*	**29**	2,207	-1,2E+12	n/a
5.	*65Cu*	*2,207*	**29**	*5,12*	*m*	*66Cu*	126,6	*66Zn*	**36,4**	2,544	-4,2E+13	n/a
6.	68Zn	2,369	**20,7**	56,4	m	69Zn	75,4	69Ga	**118,7**	1,358	7,9E+12	12,90
7.	68Zn	2,369	**20,7**	13,76	h*	$69Zn^m$	*110,9*	69Ga	**118,7**	1,358	3,7E+11	11,56
8.	*70Zn*	*0,893*	**10,9**	*2,45*	*m*	*71Zn*	48,26	*71Ga*	**106,4**	1,176	-3,4E+14	n/a
9.	*70Zn*	*0,893*	**10,9**	*3,96*	*h*	$71Zn^m$	48,26	*71Ga*	**106,4**	1,176	-3,5E+12	n/a
10.	69Ga	1,358	**118,7**	21,14	m	70Ga	301,5	70Ge	**89,1**	1,387	1,6E+12	12,22
11.	71Ga	1,176	**106,4**	14,095	h	72Ga	*267,6*	72Ge	**53,1**	1,513	-1,7E+10	n/a
12.	74Ge	1,638	**37,4**	82,78	m	75Ge	*203,1*	75As	**355**	0,817	-7,7E+11	n/a
13.	75As	0,817	**355**	1,0942	d	76As	*469,6*	76Se	**168**	0,748	4,9E+11	11,69
14.	78Se	1,164	**61,1**	2,95E+05	y	79Se	263	79Br	**622**	0,775	-7,8E+03	n/a
15.	80Se	1,49	**38**	18,45	m	81Se	229	81Br	**239**	0,766	-1,6E+12	n/a
16.	80Se	1,49	**38**	57,28	m*	$81Se^m$	229	81Br	**239**	0,766	-5,1E+11	n/a
17.	79Br	0,775	**622**	17,68	m	80Br	790	80Kr	**274**	0,009	3,6E+13	13,56
18.	79Br	0,775	**622**	4,4205	h*	$80Br^m$	790	80Kr	**90,4**	0,009	7,8E+12	12,89
19.	81Br	0,766	**239**	35,282	h	82Br	*390,5*	82Kr	**93**	0,716	1,0E+11	11,00
20.	84Kr	1,408	**32,6**	3916,8	d	85Kr	**73**	85Rb	**234**	0,709	-3,1E+07	n/a
21.	84Kr	1,408	**32,6**	4,78	h79%	$85Kr^m$	**73**	85Rb	**234**	0,709	-6,2E+11	n/a
22.	86Kr	0,893	**4,76**	76,3	m	87Kr	18	87Rb	**15,7**	0,316	4,5E+12	12,65
23.	85Rb	0,709	**234**	18,642	d	86Rb	202	86Sr	**63,5**	0,365	5,6E+10	10,75
24.	87Rb	0,316	**15,7**	17,773	m	88Rb	110	88Sr	**6,16**	1,288	-1,5E+13	n/a
25.	88Sr	1,288	**6,16**	50,57	d	89Sr	19	89Y	**19,3**	0,667	1,0E+10	10,01

	nuc_1	**log y_1 (Si=6)**	**σ_1 (mb)**	**nuc_2**	**T_2**	**time unit**	**σ_2 (mb)**	**nuc_3**	**σ_3 (mb)**	**log y_3 (Si=6)**	**n_n (cm^{-3})**	**lg n_n**
26.	89Y	0,667	**19,3**	90	y	90Y	*149,9*	90Zr	**19,3**	0,769	-1,3E+06	n/a
27.	92Zr	0,299	**37,8**	1,53E+06	y	93Zr	96	93Nb	**265,7**	0,299	-4,4E+02	n/a
28.	93Nb	-0,156	**265,7**	2,03E+04	y	94Nb	482	94Mo	**109,6**	-0,636	2,0E+09	9,30
29.	102Ru	-0,231	**151**	39,26	d	103Ru	343	103Rh	**810**	-0,463	-3,2E+10	n/a
30.	103Rh	-0,463	**810**	42,3	s	104Rh	154	104Pd	**274**	-0,818	2,2E+15	15,35
31.	103Rh	-0,463	**810**	4,34	m*	$104Rh^m$	154	104Pd	**274**	-0,818	3,6E+14	14,56
32.	106Pd	-0,42	**244**	6,60E+06	y	107Pd	1302	107Ag	**787**	-0,602	-5,7E+00	n/a
33.	108Pd	-0,431	**218**	13,7012	h	109Pd	*236,3*	109Ag	**793**	-0,627	-1,2E+11	n/a
34.	107Ag	-0,602	**787**	2,37	m	108Ag	1788	108Cd	**202**	-1,851	6,8E+14	14,84
35.	107Ag	-0,602	**787**	438	y*	$108Ag^m$	*1383,0*	108Cd	**202**	-1,851	9,1E+06	6,96
36.	109Ag	-0,627	**793**	24,6	s	110Ag	1172	110Cd	**229,9**	-0,701	1,1E+14	14,05
37.	109Ag	-0,627	**793**	249,76	d	$110Ag^m$	1172	110Cd	**229,9**	-0,701	1,3E+08	8,11
38.	114Cd	-0,333	**135,3**	53,46	h	115Cd	290	115In	**776**	-0,754	-2,5E+10	n/a
39.	114Cd	-0,333	**135,3**	44,56	d*	$115Cd^m$	224	115In	**776**	-0,754	-1,6E+09	n/a
40.	113In	-2,103	**229**	71,9	s	114In	1308	114Sn	**134,4**	-1,599	-1,3E+13	n/a
41.	113In	-2,103	**580**	49,51	d*	$114In^m$	2595	114Sn	**134,4**	-1,599	8,1E+07	7,91
42.	115In	-0,754	**154**	14,1	s	116In	1377	116Sn	**92,3**	-0,263	-6,1E+13	n/a
43.	115In	-0,754	**622**	54,29	m	$116In^m$	1377	116Sn	**92,3**	-0,263	6,7E+11	11,83
44.	120Sn	0,097	**36,3**	27,03	h	121Sn	167	121Sb	**532**	-0,752	-3,3E+10	n/a
45.	120Sn	0,097	**36,3**	43,9	y*	$121Sn^m$	*175,4*	121Sb	**532**	-0,752	-2,2E+06	n/a
46.	122Sn	-0,745	**22,6**	129,2	d	123Sn	361	123Sb	**303**	-0,879	-4,0E+10	n/a
47.	122Sn	-0,745	**21,7**	40,06	m	$123Sn^m$	361	123Sb	**303**	-0,879	-1,9E+14	n/a
48.	121Sb	-0,752	**532**	2,7238	d	122Sb	894	122Te	**295,4**	-0,928	2,1E+10	10,31
49.	123Sb	-0,879	**303**	60,11	d	124Sb	*924,0*	124Te	**155**	-0,654	3,1E+11	11,49
50.	126Te	-0,046	**81,3**	9,35	h	127Te	*256,8*	127I	**662**	-0,046	-2,6E+11	n/a
51.	126Te	-0,046	**81,3**	109	d*	$127Te^m$	*668,6*	127I	**662**	-0,046	-3,6E+08	n/a
52.	127I	-0,046	**662**	24,99	m	128I	*679,5*	128Xe	**262,5**	0,991	-1,8E+12	n/a
53.	132Xe	0,086	**63,8**	5,243	d	133Xe	127	133Cs	**502**	-0,429	-2,7E+10	n/a
54.	133Cs	-0,429	**502**	2,0652	y	134Cs	724	134Ba	**176**	-0,963	1,5E+09	9,17
55.	138Ba	0,508	**4,13**	83,06	m	139Ba	*39,7*	139La	**32,4**	-0,351	-1,0E+12	n/a
56.	139La	-0,351	**32,4**	1,67855	d	140La	117,8	140Ce	**11,73**	0,004	3,3E+10	10,52
57.	140Ce	0,004	**11,73**	32,508	d	141Ce	76	141Pr	**111,4**	-0,777	-4,4E+09	n/a
58.	141Pr	-0,777	**111,4**	19,12	h	142Pr	361,4	142Nd	**35,1**	-0,65	5,4E+10	10,73
59.	150Sm	-1,717	**422,3**	90	y	151Sm	3040	151Eu	**3556**	0,35	-2,8E+05	n/a
60.	152Sm	-1,161	**464,8**	46,284	h	153Sm	1095	153Eu	**2567**	-1,294	-1,2E+10	n/a
61.	153Eu	-1,294	**2557**	8,59	y	154Eu	4420	154Gd	**1028**	-2,149	8,8E+07	7,95
62.	158Gd	-1,086	**323,6**	18,479	h	159Gd	*455,2*	159Tb	**1817**	-1,22	-6,3E+10	n/a

	nuc_1	**log y_1 (Si=6)**	**σ_1 (mb)**	**nuc_2**	**T_2**	**time unit**	**σ_2 (mb)**	**nuc_3**	**σ_3 (mb)**	**log y_3 (Si=6)**	**n_n (cm^{-3})**	**lg n_n**
63.	159Tb	-1,22	**1817**	72,3	d	160Tb	3240	160Dy	**890**	-2,044	3,6E+09	9,55
64.	164Dy	-0,955	**212**	2,334	h	165Dy	*284,5*	165Ho	**1237**	-1,051	-8,4E+11	n/a
65.	165Ho	-1,051	**1237**	26,83	h	166Ho	*1262,0*	166Er	**700**	-1,077	2,1E+09	9,32
66.	165Ho	-1,051	**1237**	1,20E+03	y	$166Ho^m$	*1235,3*	166Er	**700**	-1,077	5,4E+03	3,73
67.	168Er	-1,168	**319**	9,392	d	169Er	653	169Tm	**1065**	-1,423	-2,5E+09	n/a
68.	169Tm	-1,423	**1065**	128,6	d	170Tm	1870	170Yb	**768,3**	-2,124	7,2E+08	8,86
69.	174Yb	-1,103	**150,5**	4,158	d	175Yb	558	175Lu	**1219**	-1,449	-1,1E+10	n/a
70.	176Lu	-2,959	**1639**	6,6475	d	177Lu	*794,9*	177Hf	**1544**	-1,545	-5,8E+09	n/a
71.	176Lu	-2,959	**1639**	160,44	d	$177Lu^m$	*348,3*	177Hf	**1544**	-1,545	-5,5E+08	n/a
72.	176Lu	-2,959	**1639**	6	m	$177Lu^m$	*348,3*	177Hf	**1544**	-1,545	-2,1E+13	n/a
73.	180Hf	-1,265	**156,6**	42,39	d	181Hf	194	181Ta	**766**	-1,684	-2,2E+09	n/a
74.	181Ta	-1,684	**766**	114,43	d	182Ta	1120	182W	**285**	-1,455	3,0E+06	6,48
75.	184W	-1,389	**225**	75,4	d	185W	633	185Re	**1438,5**	-1,717	-4,5E+08	n/a
76.	186W	-1,423	**226**	23,72	h	187W	183	187Re	**1184**	-1,475	-1,3E+11	n/a
77.	185Re	-1,717	**1420**	3,7186	d	186Re	743	186Os	**414**	-2,06	7,0E+10	10,85
78.	185Re	-1,717	**18,5**	2,00E+05	y*	$186Re^m$	743	186Os	**414**	-2,06	-4,9E+02	n/a
79.	187Re	-1,475	**1187**	17,003	h	188Re	2343	188Os	**294**	-1,047	9,0E+09	9,96
80.	190Os	-0,75	**278**	15,4	d	191Os	1290	191Ir	**1350**	-0,607	-1,4E+09	n/a
81.	192Os	-0,558	**160**	30,11	h	193Os	*95,6*	193Ir	**994**	-0,383	-2,2E+11	n/a
82.	191Ir	-0,607	**1350**	7,38E+01	d	192Ir	2080	192Pt	**483**	-1,979	1,3E+10	10,10
83.	191Ir	-0,607	**1350**	2,41E+02	y*	$192Ir^m$	2080	192Pt	**483**	-1,979	1,1E+07	7,02
84.	193Ir	-0,383	**994**	19,28	h	194Ir	*397,8*	194Pt	**283**	-0,356	2,2E+11	11,34
85.	196Pt	-0,47	**167,4**	19,8915	h	197Pt	*175,4*	197Au	**612,8**	-0,728	-1,0E+11	n/a
86.	197Au	-0,728	**612,8**	2,70E+00	d	198Au	840	198Hg	**173**	-1,46	2,5E+11	11,39
87.	202Hg	-0,996	**63,3**	46,594	d	203Hg	98	203Tl	**170,5**	-1,265	-9,8E+10	n/a
88.	204Hg	-1,633	**42**	5,14	m	205Hg	12,7	205Tl	**52,6**	-0,886	-5,6E+14	n/a
89.	203Tl	-1,265	**170,5**	3,78	y	204Tl	215	204Pb	**83,7**	-1,207	7,8E+07	7,89
90.	205Tl	-0,866	**52,6**	4,2	m	206Tl	34,1	206Pb	**14,7**	-0,277	-2,3E+13	n/a
91.	208Pb	0,265	**0,376**	3,253	h	209Pb	*3,6*	209Bi	**2,61**	-0,842	5,1E+13	13,71

4. Isotonic equilibrium neutron density at a temperature of $3 \cdot 10^8 \mathrm{K}$

	nuc_1	**log y_1 (Si=6)**	**σ_1 (mb**	**T_2**	**time unit**	**nuc_2**	**σ_2 (mb)**	**nuc_3**	**σ_3 (mb)**	**log y_3 (Si=6)**	**n_n (cm^{-3})**	**lg n_n**
1.	58Fe	3,473	**13,3**	44,4495	d	59Fe	**26,4**	59Co	**40,1**	3,352	-1,41E+10	n/a
2.	59Co	3,352	**40,1**	1925,28	d	60Co	*12,64*	60Ni	**29,9**	4,11	-2,85E+10	n/a
3.	62Ni	3,255	**22,2**	100,1	y	63Ni	***66,7***	63Cu	**53,7**	2,558	9,50E+07	7,98

	nuc_1	**log y_1 (Si=6)**	**σ_1 (mb**	**T_2**	**time unit**	**nuc_2**	**σ_2 (mb)**	**nuc_3**	**σ_3 (mb)**	**log y_3 (Si=6)**	**n_n (cm^{-3})**	**lg n_n**
4.	*64Ni*	*2,726*	**8**	*2,5172*	*h*	*65Ni*	21,2	*65Cu*	**29**	2,207	-1,18E+12	n/a
5.	*65Cu*	*2,207*	**29**	*5,12*	*m*	*66Cu*	126,6	*66Zn*	**36,4**	2,544	-4,14E+13	n/a
6.	68Zn	2,369	**20,7**	56,4	m	69Zn	75,4	69Ga	**118,7**	1,358	7,89E+12	12,90
7.	68Zn	2,369	**20,7**	13,76	h*	$69Zn^m$	*110,9*	69Ga	**118,7**	1,358	3,67E+11	11,56
8.	*70Zn*	*0,893*	**10,9**	*2,45*	*m*	*71Zn*	48,26	*71Ga*	**106,4**	1,176	-3,37E+14	n/a
9.	*70Zn*	*0,893*	**10,9**	*3,96*	*h*	$71Zn^m$	48,26	*71Ga*	**106,4**	1,176	-3,48E+12	n/a
10.	69Ga	1,358	**118,7**	21,14	m	70Ga	301,5	70Ge	**89,1**	1,387	1,64E+12	12,22
11.	71Ga	1,176	**106,4**	14,095	h	72Ga	*267,6*	72Ge	**53,1**	1,513	-7,81E+10	n/a
12.	74Ge	1,638	**37,4**	82,78	m	75Ge	*203,1*	75As	**355**	0,817	-7,49E+11	n/a
13.	75As	0,817	**355**	1,0942	d	76As	*469,6*	76Se	**168**	0,748	1,40E+13	13,15
14.	78Se	1,164	**61,1**	2,95E+05	y	79Se	***263***	79Br	**622**	0,775	-1,39E+07	n/a
15.	80Se	1,49	**38**	18,45	m	81Se	229	81Br	**239**	0,766	-1,48E+12	n/a
16.	80Se	1,49	**38**	57,28	m*	$81Se^m$	229	81Br	**239**	0,766	-4,78E+11	n/a
17.	79Br	0,775	**622**	17,68	m	80Br	790	80Kr	**274**	0,009	2,42E+13	13,38
18.	79Br	0,775	**622**	4,4205	h*	$80Br^m$	790	80Kr	**90,4**	0,009	5,15E+12	12,71
19.	81Br	0,766	**239**	35,282	h	82Br	**390,5**	82Kr	**93**	0,716	1,05E+12	12,02
20.	84Kr	1,408	**32,6**	3916,8	d	85Kr	**73**	85Rb	**234**	0,709	-3,23E+07	n/a
21.	84Kr	1,408	**32,6**	4,78	h79%	$85Kr^m$	**73**	85Rb	**234**	0,709	-6,35E+11	n/a
22.	86Kr	0,893	**4,76**	76,3	m	87Kr	18	87Rb	**15,7**	0,316	4,48E+12	12,65
23.	85Rb	0,709	**234**	18,642	d	86Rb	202	86Sr	**63,5**	0,365	5,60E+10	10,75
24.	87Rb	0,316	**15,7**	17,773	m	88Rb	110	88Sr	**6,16**	1,288	-1,14E+13	n/a
25.	88Sr	1,288	**6,16**	50,57	d	89Sr	19	89Y	**19,3**	0,667	1,03E+10	10,01
26.	89Y	0,667	**19,3**	90	y	90Y	*149,9*	90Zr	**19,3**	0,769	-1,26E+06	n/a
27.	92Zr	0,299	**37,8**	1,53E+06	y	93Zr	96	93Nb	**265,7**	0,299	-1,58E+03	n/a
28.	93Nb	-0,156	**265,7**	2,03E+04	y	94Nb	482	94Mo	**109,6**	-0,636	4,04E+10	10,61
29.	102Ru	-0,231	**151**	39,26	d	103Ru	343	103Rh	**810**	-0,463	-3,59E+10	n/a
30.	103Rh	-0,463	**810**	42,3	s	104Rh	154	104Pd	**274**	-0,818	1,73E+15	15,24
31.	103Rh	-0,463	**810**	4,34	m*	$104Rh^m$	154	104Pd	**274**	-0,818	2,80E+14	14,45
32.	106Pd	-0,42	**244**	6,60E+06	y	107Pd	1302	107Ag	**787**	-0,602	-4,02E+04	n/a
33.	108Pd	-0,431	**218**	13,7012	h	109Pd	*236,3*	109Ag	**793**	-0,627	-1,24E+11	n/a
34.	107Ag	-0,602	**787**	2,37	m	108Ag	1788	108Cd	**202**	-1,851	5,96E+14	14,77
35.	107Ag	-0,602	**787**	438	y*	$108Ag^m$	*1383,0*	108Cd	**202**	-1,851	7,92E+06	6,90
36.	109Ag	-0,627	**793**	24,6	s	110Ag	1172	110Cd	**229,9**	-0,701	1,03E+14	14,01
37.	109Ag	-0,627	**793**	249,76	d	$110Ag^m$	1172	110Cd	**229,9**	-0,701	1,18E+08	8,07
38.	114Cd	-0,333	**135,3**	53,46	h	115Cd	290	115In	**776**	-0,754	-2,47E+10	n/a

	nuc_1	**log y_1 (Si=6)**	**σ_1 (mb**	**T_2**	**time unit**	**nuc_2**	**σ_2 (mb)**	**nuc_3**	**σ_3 (mb)**	**log y_3 (Si=6)**	**n_n (cm^{-3})**	**lg n_n**
39.	114Cd	-0,333	**135,3**	44,56	d*	$115Cd^m$	224	115In	**776**	-0,754	-1,60E+09	n/a
40.	113In	-2,103	**229**	71,9	s	114In	1308	114Sn	**134,4**	-1,599	-1,26E+13	n/a
41.	113In	-2,103	**580**	49,51	d*	$114In^m$	2595	114Sn	**134,4**	-1,599	8,07E+07	7,91
42.	115In	-0,754	**154**	14,1	s	116In	1377	116Sn	**92,3**	-0,263	-5,91E+13	n/a
43.	115In	-0,754	**622**	54,29	m	$116In^m$	1377	116Sn	**92,3**	-0,263	6,51E+11	11,81
44.	120Sn	0,097	**36,3**	27,03	h	121Sn	167	121Sb	**532**	-0,752	-2,40E+10	n/a
45.	120Sn	0,097	**36,3**	43,9	y*	$121Sn^m$	*175,4*	121Sb	**532**	-0,752	-1,60E+06	n/a
46.	122Sn	-0,745	**22,6**	129,2	d	123Sn	361	123Sb	**303**	-0,879	-3,00E+11	n/a
47.	122Sn	-0,745	**21,7**	40,06	m	$123Sn^m$	361	123Sb	**303**	-0,879	-1,40E+15	n/a
48.	121Sb	-0,752	**532**	2,7238	d	122Sb	894	122Te	**295,4**	-0,928	7,76E+10	10,89
49.	123Sb	-0,879	**303**	60,11	d	124Sb	*924,0*	124Te	**155**	-0,654	5,00E+11	11,70
50.	126Te	-0,046	**81,3**	9,35	h	127Te	*256,8*	127I	**662**	-0,046	-2,23E+11	n/a
51.	126Te	-0,046	**81,3**	109	d*	$127Te^m$	*668,6*	127I	**662**	-0,046	-3,06E+08	n/a
52.	127I	-0,046	**662**	24,99	m	128I	*679,5*	128Xe	**262,5**	0,991	-1,83E+12	n/a
53.	132Xe	0,086	**63,8**	5,243	d	133Xe	127	133Cs	**502**	-0,429	-3,64E+10	n/a
54.	133Cs	-0,429	**502**	2,0652	y	134Cs	724	134Ba	**176**	-0,963	9,52E+10	10,98
55.	138Ba	0,508	**4,13**	83,06	m	139Ba	*39,7*	139La	**32,4**	-0,351	-1,02E+12	n/a
56.	139La	-0,351	**32,4**	1,67855	d	140La	117,8	140Ce	**11,73**	0,004	4,11E+10	10,61
57.	140Ce	0,004	**11,73**	32,508	d	141Ce	76	141Pr	**111,4**	-0,777	-4,35E+09	n/a
58.	141Pr	-0,777	**111,4**	19,12	h	142Pr	361,4	142Nd	**35,1**	-0,65	3,60E+10	10,56
59.	150Sm	-1,717	**422,3**	90	y	151Sm	3040	151Eu	**3556**	0,35	-7,31E+06	n/a
60.	152Sm	-1,161	**464,8**	46,284	h	153Sm	1095	153Eu	**2567**	-1,294	-1,81E+10	n/a
61.	153Eu	-1,294	**2557**	8,59	y	154Eu	4420	154Gd	**1028**	-2,149	1,08E+10	10,03
62.	158Gd	-1,086	**323,6**	18,479	h	159Gd	*455,2*	159Tb	**1817**	-1,22	-6,09E+10	n/a
63.	159Tb	-1,22	**1817**	72,3	d	160Tb	3240	160Dy	**890**	-2,044	2,52E+11	11,40
64.	164Dy	-0,955	**212**	2,334	h	165Dy	*284,5*	165Ho	**1237**	-1,051	-8,43E+11	n/a
65.	165Ho	-1,051	**1237**	26,83	h	166Ho	*1262,0*	166Er	**700**	-1,077	1,16E+10	10,07
66.	165Ho	-1,051	**1237**	1,20E+03	y	$166Ho^m$	*1235,3*	166Er	**700**	-1,077	3,03E+04	4,48
67.	168Er	-1,168	**319**	9,392	d	169Er	653	169Tm	**1065**	-1,423	-2,40E+09	n/a
68.	169Tm	-1,423	**1065**	128,6	d	170Tm	1870	170Yb	**768,3**	-2,124	7,95E+08	8,90
69.	174Yb	-1,103	**150,5**	4,158	d	175Yb	558	175Lu	**1219**	-1,449	-1,64E+10	n/a
70.	176Lu	-2,959	**1639**	6,6475	d	177Lu	*794,9*	177Hf	**1544**	-1,545	-8,18E+09	n/a
71.	176Lu	-2,959	**1639**	160,44	d	$177Lu^m$	*348,3*	177Hf	**1544**	-1,545	-7,73E+08	n/a
72.	176Lu	-2,959	**1639**	6	m	$177Lu^m$	*348,3*	177Hf	**1544**	-1,545	-2,98E+13	n/a
73.	180Hf	-1,265	**156,6**	42,39	d	181Hf	194	181Ta	**766**	-1,684	-5,63E+10	n/a
74.	181Ta	-1,684	**766**	114,43	d	182Ta	1120	182W	**285**	-1,455	5,21E+08	8,72
75.	184W	-1,389	**225**	75,4	d	185W	633	185Re	**1438,5**	-1,717	-4,83E+08	n/a

	nuc_1	$\log y_1$ (Si=6)	σ_1 (mb	T_2	time unit	nuc_2	σ_2 (mb)	nuc_3	σ_3 (mb)	$\log y_3$ (Si=6)	n_n (cm^{-3})	lg n_n
76.	186W	-1,423	**226**	23,72	h	187W	183	187Re	**1184**	-1,475	-1,41E+11	n/a
77.	185Re	-1,717	**1420**	3,7186	d	186Re	743	186Os	**414**	-2,06	7,48E+10	10,87
78.	185Re	-1,717	**18,5**	2,00E+05	y*	$186Re^m$	743	186Os	**414**	-2,06	-5,23E+02	n/a
79.	187Re	-1,475	**1187**	17,003	h	188Re	2343	188Os	**294**	-1,047	9,50E+09	9,98
80.	190Os	-0,75	**278**	15,4	d	191Os	1290	191Ir	**1350**	-0,607	-2,58E+09	n/a
81.	192Os	-0,558	**160**	30,11	h	193Os	*95,6*	193Ir	**994**	-0,383	-2,05E+11	n/a
82.	191Ir	-0,607	**1350**	7,38E+01	d	192Ir	2080	192Pt	**483**	-1,979	1,76E+10	10,24
83.	191Ir	-0,607	**1350**	2,41E+02	y*	$192Ir^m$	2080	192Pt	**483**	-1,979	1,47E+07	7,17
84.	193Ir	-0,383	**994**	19,28	h	194Ir	*397,8*	194Pt	**283**	-0,356	3,47E+11	11,54
85.	196Pt	-0,47	**167,4**	19,8915	h	197Pt	*175,4*	197Au	**612,8**	-0,728	-1,19E+11	n/a
86.	197Au	-0,728	**612,8**	2,70E+00	d	198Au	840	198Hg	**173**	-1,46	9,52E+11	11,98
87.	202Hg	-0,996	**63,3**	46,594	d	203Hg	98	203Tl	**170,5**	-1,265	-1,40E+11	n/a
88.	204Hg	-1,633	**42**	5,14	m	205Hg	12,7	205Tl	**52,6**	-0,886	-5,59E+14	n/a
89.	203Tl	-1,265	**170,5**	3,78	y	204Tl	215	204Pb	**83,7**	-1,207	1,55E+10	10,19
90.	205Tl	-0,866	**52,6**	4,2	m	206Tl	34,1	206Pb	**14,7**	-0,277	-2,32E+13	n/a
91.	208Pb	0,265	**0,376**	3,253	h	209Pb	*3,6*	209Bi	**2,61**	-0,842	5,10E+13	13,71

Legend

n/a: not all third nuclei can be achieved in that process

log y_i: D. Arnett: *Supernovae and Nucleosynthesis*, Princeton University Press, 1996

at σ_i :

bold: KADoNiS 1.0

normal: KADoNiS 0.3 (MACS)

italic: B. Pritychenko,∗ S.F. Mughabghab: Neutron Thermal Cross Sections, Westcott Factors, Resonance Integrals, Maxwellian Averaged Cross Sections and Astrophysical Reaction Rates Calculated from the ENDF/B-VII.1, JEFF-3.1.2, JENDL-4.0, ROSFOND-2010, CENDL-3.1 and EAF-2010 Evaluated Data Libraries

underlined: http://adg.llnl.gov/Research/RRSN/aemr/30kev/rath00_7.4.30kev_calc