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BETA-DECAY RATES FOR THE s-PROCESS

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Abstract

The β-decay rates under s-process conditions are presented for heavy nuclei in the ranges $26 \leq Z \leq 83$ and $59 \leq A \leq 210$. The types of β-decay processes taken into account in the calculation are continuum-state β^--decay, bound-state β^--decay, bound-electron capture, continuum-electron capture and continuum-state β^+-decay. The rates are calculated at various temperatures ($1\times10^8 \leq T \leq 5\times10^8$ K) and electron number densities ($3\times10^{26} \leq n_e \leq 3\times10^{27}$ cm^{-3}). It is emphasized that the bound-state β^--decay is of importance for the study of s-process nucleosynthesis.

Beta Zerfallsraten für den s-Prozeß

Zusammenfassung

Die Beta Zerfallsraten unter s-Prozeß-Bedingungen werden für schwere Kerne in den Bereichen $26 \leq Z \leq 83$ und $59 \leq A \leq 210$ vorgestellt. In der Berechnung wurden β^--Zerfälle ins Kontinuum und in gebundene Zustände, Elektroneneinfang aus gebundenen Zuständen und aus dem Kontinuum sowie β^+-Zerfälle ins Kontinuum berücksichtigt. Die Raten wurden für verschiedene Temperaturen ($1\times10^8 \leq T \leq 5\times10^8$ K) und Elektronendichten ($3\times10^{26} \leq n_e \leq 3\times10^{27}$ cm^{-3}) durchgeführt. Man findet, daß die β^--Zerfälle in gebundene Zustände für s-Prozeß-Untersuchungen besonders wichtig sind.

Introduction

In the canonical treatment of the s-process[1], it is assumed that β-decays of unstable nuclei always occur before neutron captures, except for some long-lived nuclei. However, several studies[2-5] of the steady flow s-process model show that the consideration of competitions between β-decays and neutron captures at various nuclei along the path is of great importance to evaluate the average temperature and neutron density conditions for the solar-system s-process material. Further, in the performance of more realistic s-process network calculations[6], it is indispensable to consider s-process branchings.

The global surveys of β-decays required in the s-process branching study have been done by several authors[7-9]. Calculations of β-decay rates of nuclei under s-process conditions are, however, subject to various uncertainties which arise from the treatment of ionic states, estimates for ft-values of unknown transitions, and the lack of experimental data of nuclear excited states.

With this background, we present tables of β-decay rates for heavy nuclei on the s-process path. The calculation is based on a recent formalism[10] of β-decays in a mixture of ions and electrons in a plasma. The theory is suitable for studies of low-energy β-decays, particularly of bound-state β^--decays and of bound-electron capture in highly ionized atoms. Some important astrophysical consequences of bound-state β^--decays have already been emphasized recently in connection with the cosmochronology[11,12] and s-process branchings[3,13,14].

Method of Calculation

The present approach of calculations is described in detail in Ref. 10. In the following, we briefly summarize the method of calculation. We use the Saha equation to obtain the population of differently ionized states of non-relativistic, non-degenerate element i under the assumption of local thermodynamical equilibrium. The Saha equation is written by

$$n_{ij+1}/n_{ij} = (b_{ij+1}/b_{ij})(M_{ij+1}/M_{ij})^{3/2}\exp[-\chi_{ij}/(\kappa T)-\eta], \qquad (1)$$

where n_{ij} is the number density of element i in its j-times ionized state, b_{ij} the atomic partition function, M_{ij} the mass, χ_{ij} the ionization potential, κ the Boltzmann constant and T the temperature. The electron degeneracy parameter η is related to the free electron number density n_e by

$$n_e = F(\eta,\ \beta)/(\pi^2\lambda\!\!\!^{-}{}^3), \qquad (2)$$

where $\lambda\!\!\!^{-}=\hbar/(m_e c)$, $\beta=m_e c^2/\kappa T$ and the relativistic Fermi-Dirac integral

$$F(\eta,\ \beta) = \int_1^\infty W(W^2-1)^{1/2} f_{FD}(\eta,\ \beta)dW, \qquad (3)$$

with

$$f_{FD}(\eta,\ \beta) = [1+\exp(\beta(W-1)-\eta)]^{-1}. \qquad (4)$$

The s-process is currently believed to occur in helium rich matter. Since helium atoms are almost fully ionized under high temperature circumstances, the abundances n_{ij} of element i embedded as a tiny remainder in the matter are determined for a set of T and n_e, provided that all the b_{ij}, χ_{ij} and M_{ij} are known.

The potential distribution in and near an ion is influenced not only by its own bound electrons, but also by the surrounding free electrons and neighboring ions, so that the effective ionization potential χ_{ij} is expected to be smaller than the laboratory value I_{ij}

by a certain amount Δ_{ij}:

$$\chi_{ij} = I_{ij} - \Delta_{ij}. \qquad (5)$$

The uncorrected ionization potential I_{ij} is approximately given by

$$I_{ij} = I^0_{ij}(1 - c_j/Z_i + d_j/Z_i^2), \qquad (6)$$

where I^0_{ij} is the hydrogenic ionization potential and Z_i is the nuclear charge of element i. The adjustable parameters c_j and d_j have been determined by the fit of Eq. (6) to the ionization potentials calculated from the relativistic self-consistent method[15]. For the correction Δ_{ij}, an approximate expression[10] has been used.

The atomic partition function b_{ij} in Eq. (1) is defined by

$$b_{ij} = \Sigma_k b_{ijk} \exp(-e^*_{ijk}/\kappa T), \qquad (7)$$

where b_{ijk} and e^*_{ijk} are the statistical weight and the excitation energy of the k-th atomic level of the j-times ionized element i, respectively. For the evaluation of b_{ij}, the conventional cut-off method has been applied for simplicity. Since the existing experimental data are hardly sufficient for calculating b_{ij} for most of the heavy ions, theoretical values have been derived from the single-particle eigen-energies for the ground-state configuration by particle-hole excitations.

In the present work, we deal with allowed (a), non-unique first-forbidden (nu) and unique first-forbidden (u) transitions which play decisive roles in determining the total effective β-decay rates of the vast majority of nuclei. The decay rates from the initial state I to the final state F, which are specified by the nuclear and atomic states, and the degree of ionization, may then be written by

$$\lambda_{IF}^{(m)} = \begin{cases} [\ln 2/(f_0 t)] f^{*}_{IF(m)} & \text{for } m=a,\ nu, \\ [\ln 2/(f_1 t)] f^{*}_{IF(m)} & \text{for } m=u, \end{cases} \tag{8}$$

where use is made of the ft values of the corresponding "terrestrial" transitions, while the function $f^{*}_{IF(m)}$ expresses the respective lepton phase volume, which depends on T and n_e in stellar circumstances[10]. For the ft values, those of experimentally known transitions are used where available; otherwise, a guess is made of the ft values, which is explained later for some examples. There are some cases (e.g. ^{60}Fe, ^{87}Rb, ^{113}Cd etc.) where the transitions from the ground states are higher forbidden . Nevertheless, we apply the same shape factor as for allowed transitions to those higher forbidden cases. Although this leads to some errors in the calculation, it does not matter for the practical purpose, because either the total effective decay rates are dominantly determined by other faster transitions from the excited states or the neutron capture processes are much faster than the β-decays.

The effective decay rate of the K-th nuclear excited state of element i may be given by

$$\lambda_{i(K)} = \Sigma_j n_{ij} \lambda_{i(K)j} / \Sigma_j n_{ij}, \tag{9}$$

with

$$\lambda_{i(K)j} = [\Sigma_{K'kk'} b_{ijk} \exp(-e^{*}_{ijk}/\kappa T) \lambda_{IF}^{(m)}] / \Sigma_k b_{ijk} \exp(-e^{*}_{ijk}/\kappa T)], \tag{10}$$

where K' and k' represent final nuclear and atomic states, respectively, and m specified by K and K' is either a, nu or u as described before.

Under the assumption that the nuclear states are in thermal equilibrium, the total effective rate of element i is given by

$$\lambda_i = \Sigma_K[G_{iK}\exp(-E^*_{iK}/\kappa T)\lambda_{i(K)}] / \Sigma_K G_{iK}\exp(-E^*_{iK}/\kappa T), \qquad (11)$$

where G_{iK} and E^*_{iK} are the statistical weight and the excitation energy of the K-th initial nuclear state, respectively. In the present work, the nuclei are always assumed to be fully thermalized, so that Eq. (11) is applied to all the cases. Although this equation is appropriate in most cases, caution must be paid to some nuclei with long-lived isomeric states, in which the equilibration time-scale may be comparable to or even longer than the time-scales of other nuclear reactions and/or of changes in astrophysical conditions. If so, Eq. (11) should be disregarded[16,17]. Instead, the summation over the nuclear levels K should be taken according to their populations which vary with time as a result of nuclear excitatons, de-excitations and destruction mechanisms following the precursory reaction.

Nuclear level schemes were taken from Lederer and Shirley[18], Nuclear Data Sheets (up to volume 40) and recent publications. All excited states in the parent nucleus below 300 keV, from which the transitions are expected to be significant under s-process temperature conditions, are considered in the calculation.

The types of the β-decay processes considered in the present work are continuum-state β^--decay, bound-state β^--decay, bound-electron capture, continuum-electron capture and continuum-state β^+-decay. Among these decay modes, we wish to emphasize the importance of bound-state β^--decay for s-process studies, which has often been overlooked. When the neutral atomic mass difference between the initial and final atoms (i.e. the usual Q-value) is small, the bound-state β^--decays significantly contribute to the total decay rates. Through this mechanism, even a stable nucleus could undergo the β^--decay with a non-negligible rate if the electron capture Q-value is small enough. Figures 1a and 1b show respectively the ratios between the rates of the bound-state β^--decay $\lambda_{b\beta^-}$ and of the continuum-state β^--decay $\lambda_{c\beta^-}$ for allowed (or non-unique first forbidden) and unique first forbidden transitions, provided that the atoms are completely ionized. Note that the ratios actually depend on T and n_e in the stellar environment. As seen from these figures, the ratio $\lambda_{b\beta^-}/\lambda_{c\beta^-}$

increases with decreasing Q-value, and finally the continuum-state β^--decay rate becomes zero at a critical value.

ft Values of Unknown Transitions

An important and difficult task in the calculation of β-decay rates in high temperature s-process environments is to estimate the ft values of unknown transitions of thermally populated excited states. They might be estimated by using appropriate nuclear models. However, it is not easy to handle fairly sophisticated models, and they do not always give satisfactory results. Further, we must know the ft values of many individual unknown transitions for nuclei covering different mass regions. In some cases, we must also deal with transitions to rather complicated states caused by various modes of excitations.

In the present work, we estimate the ft values of unknown transitions on the basis of properties of nuclear states and general trends of the reduced matrix elements of known analogous transitions in neighbouring nuclei. Although the ft values thus determined are, of course, inescapably in danger of being considerably uncertain, the present procedure is expected to be much more reasonable than applying identical ft values to all unknown transitions which are simply classified by usual spin-parity selection rules[9].

In the following, we describe some typical examples of β^--decays of nuclei (see Fig. 2) in which unknown transitions of excited states may be of importance for the study of s-process nucleosynthesis and the associated cosmochronology.

(1) ^{79}Se

The branching at ^{79}Se along with that of ^{85}Kr is well suited to provide an estimate for average temperature and neutron density conditions of the s-process responsible for light ($A \lesssim 85$) s-process nuclei[4]. The possibility that the β-decay rate of ^{79}Se is largely enhanced in high temperature conditions was first emphasized by Cameron[19]. Among transitions of excited states of ^{79}Se, the most crucial one may be the transition of the $1/2^-$, 95.7 keV first excited state to the $3/2^-$ ground state of ^{79}Br. The probable shell model assignments for the $1/2^-$ state of ^{79}Se and the $3/2^-$ ground state of ^{79}Br are $(2p_{1/2})_n$ and $(2p_{3/2})_p$, respectively. Based on analogous oddjumping transitions of neighbouring odd-A nuclei, we adopt 5.0 for the log ft value of this transition. On the other hand, the transition from the $1/2^-$ (or $3/2^-$), 128 keV state which has been reported to be a component of the doublet at about 130 keV in (d,p) and (d,t) reactions[20-22] is presumably much slower than that from the $1/2^-$, 95.7 keV state because the transition to the 128 keV state from the $3/2^-$ ground state of ^{79}As is not observed. The neglect of the transition of the 128 keV state does not cause serious changes in the effective decay rates. Further, the transitions of other excited states may be of minor importance, although they are taken into account in the calculation.

(2) ^{134}Cs

The branching at ^{134}Cs concerns the production of s-process only isotopes ^{134}Ba and ^{136}Ba[2]. From neighbouring odd-mass nuclei, it is likely that low-lying states of ^{134}Cs are formed by coupling a $1g_{7/2}$ or $2d_{5/2}$ proton orbit and a $3s_{1/2}$, $1h_{11/2}$ or $2d_{3/2}$ neutron orbit. The 5^+, 11.2 keV first excited state undergoes allowed transitions to 4^+ states at 1401 and 1970 keV of ^{134}Ba which may be two- and three-phonon states, respectively. For these transitions, we use the log ft values close to those of analogous transitions from the ^{136}Cs ground state which has a structure similar to that of the 5^+ excited state. The transitions of the 5^+ state would not appreciably influence the effective decay rates. On the other hand, the decay scheme of the 3^+ second excited state may be different from that of the 5^+ state. The log ft values of similar transitions observed in neighbouring nuclei such as ^{130}La and ^{138}Pm are relatively small, so that it is expected that the transitions of the 3^+ state to phonon states are rather fast. In addition, since the probable configuration of the 1^+, 176.6 keV state in ^{134}Cs is $(2d_{5/2})_p(2d_{3/2})_n$, the non-ℓ-forbidden transition to the ^{134}Ba ground state would be also fast. Therefore, the effective decay rates may be considerably different from the terrestrial value.

(3) ^{148}Pm

A recent measurement of neutron capture cross sections of the s-process only isotopes ^{148}Sm and ^{150}Sm shows that a small but significant fraction of the s-process flow bypasses ^{148}Sm[5]. This fact can then be used to evaluate average s-process conditions. Among β-decay processes of relevant nuclei along the s-process path in the mass region 146≤A≤150, we select here the β^--decay of ^{148}Pm, as it shows a typical example of importance of transitions to rather complicated states. The level scheme of ^{148}Pm is still not well known. Apart from the 1^- ground state, only the 2^- and 6^- excited states have been observed so far. The β^--decay half-life of the 6^- isomeric state as well as the ground state has been experimentally determined. From neighbouring odd-A nuclei, these three states are presumably formed by coupling a $5/2^+$ or $7/2^+$ proton orbit and a $5/2^-$ or $7/2^-$ neutron orbit. As the structure of the 2^- state would be similar to that of the 1^- ground state, it seems reasonable to assume that the ft value of the non-unique first forbidden transition of the 2^- state to the 2^+ first excited state of ^{148}Sm is not significantly different from that of the ground state. While the transition of the ground state to the 3^-, 1161.2 keV state of ^{148}Sm is second forbidden, the corresponding transition of the 2^- state is allowed, so that it might be thought that the ft value of the transition of the 2^- state is much smaller than that of the 1^- state. However, the 3^- is probably an octupole vibration[23], and allowed transitions to such states in this mass region are observed to have large log ft values in the range 7.6-8.9. In addition, the allowed transition of the 2^- state to the 1^-, 1465.1 keV state which may arise from the coupling of a quadrupole vibration to the fundamental octupole vibration[23] would be highly retarded. Although the adopted log ft values shown in Fig. 2c are quite uncertain, the transitions of the 2^- state would not significantly influence the effective decay rates.

(4) ^{160}Tb

The β^--decay of ^{160}Tb is of particular importance for the study of the ^{176}Lu-^{176}Hf nucleochronometer[24]. If the β^--decay of ^{160}Tb is much faster than its neutron capture during the neutron irradiation, ^{160}Dy can then be used as a suitable reference. This would require an enhanced decay rate of ^{160}Tb. Since the Nilsson state $\{3/2^+[411]_p$-$5/2^-[523]_n\}$ of the 1^-, 63.7 keV state of ^{160}Tb is the same[25,26] as that of the ground state of ^{162}Tb, and since the level schemes of the daughter nuclei ^{160}Dy and ^{162}Dy are quite analogous, the transitions of the 1^- excited state are expected to be similar to those of the ^{162}Tb ground state. In particular, the transition to the 2^- two-quasiparticle state at 1264.7 keV of ^{160}Dy is probably an allowed unhindered $5/2^-[523]_n \to 7/2^-[523]_p$ transition, which is analogous to that from the ground state of ^{162}Tb to the 2^-, 1148.3 keV state of ^{162}Dy with log ft=4.8. After correcting for the pairing effect through a simple BCS model[27,28], we obtain log ft=4.6. The ft values for transitions of other members of the $K^\pi=1^-$ band are estimated by using the intensity rule[29]. Since these transitions are very fast, the transitions of other low-lying excited states which are either (K-)forbidden or hindered, are unimportant.

(5) ^{170}Tm

The β^--decay of ^{170}Tm as well as that of ^{160}Tb is concerned with the ^{176}Lu-^{176}Hf chronometer[30]. The 2^- first and 3^- second excited states of ^{170}Tm are members of the $K^\pi=1^-$ ground-state band. Therefore, it is expected that the log ft values of non-unique first forbidden transitions of these states to the 2^+ first excited state of ^{170}Yb are not so different from that of the ground state (log ft=9.3), which is known to be an indication in favour of an effect of the Λ-selection rule[31]. On the other hand, the 0^-, 149.7 keV state of ^{170}Tm has the probable configuration of $\{1/2^+[411]_p$-$1/2^-[521]_n\}$[32], so that the transition to the ground state of ^{170}Yb may be classified non-unique first forbidden unhindered. The allowed transitions of the 3^+, 183 keV state to the 2^+ and 4^+ members of the ground-state band may be highly retarded, as they are $\Delta K=3$ transitions.

(6) ^{181}Hf

It has been recently proposed that ^{182}Hf is a potential chronometer to the early solar system[33]. In Ref. 33, ^{182}Hf was regarded as a r-process only nucleus, because the instability of ^{181}Hf prevents the s-process from reaching ^{182}Hf. This argument is, however, not clear without a detailed study of the branching at ^{181}Hf. It is possible that there is a non-negligible neutron capture branching unless the effective β^--decay rates of ^{181}Hf are significantly enhanced at s-process temperatures. In this respect, the transitions from the $9/2^+$, 68 keV state of ^{181}Hf to the $7/2^+$ ground state and the $9/2^-$, 62.1 keV first excited state of ^{181}Ta would be important. These transitions may be classified allowed hindered ($9/2^+[624]_n \rightarrow 7/2^+[404]_p$) and non-unique first forbidden unhindered ($9/2^+[624]_n \rightarrow 9/2^-[514]_p$), respectively. Averaging ft values of analogous transitions which are corrected for pairing effects, we obtain log ft=6.9 and 6.8 for the transitions from the $9/2^+$ state to the $7/2^+$ and $9/2^-$ states, respectively.

Results and Discussion

We have calculated the β-decay rates for heavy nuclei ($26 \leq Z \leq 83$, $59 \leq A \leq 210$) along the s-process path at various temperatures $1 \times 10^8 \leq T \leq 5 \times 10^8$ K and electron number densities $3 \times 10^{26} \leq n_e \leq 3 \times 10^{27}$ cm^{-3}. The results are presented in Tables I, II and III (see also explanations of tables). The contribution of each decay mode can be estimated from these tables. In particular, it is clearly seen from Table I that the bound-state β^--decay is significant for nuclei whose β^--decay Q-values are either small or negative.

It is difficult to estimate the uncertainties of the present rates if unknown transitions from low-lying excited states are involved. This is mainly due to the difficulty of estimating the ft values of these unknown transitions. As mentioned before, the adopted ft values are inescapably in danger of being considerably uncertain. Therefore, it is always desirable to investigate the actual influence of changes in the β-decay rates on the particular application.

It would be interesting to compare the present results with those of Cosner and Truran[9], which have often been used in s-process studies. Figure 3a shows the comparison for the total effective β^--decay rates at $T=3 \times 10^8$ (K) and $n_e=10^{27}$ (cm^{-3}). In the work of Cosner and Truran[9], the experimentally known β-decay rates were used where available; otherwise, average ft values were applied to all unknown transitions classified by the usual degree of forbiddenness. The bound-state β^--decay was neglected. The observed discrepancies are mainly attributed to the adopted ft values of unknown transitions and the contribution of the bound-state β^--decay, but to some extent due to the incorrect shape factor for the unique first forbidden transitions used in Ref. 9. As seen from Figure 3a, the agreement is fairly good for nuclei in the intermediate mass region ($50 \lesssim A \lesssim 140$), although there are considerable discrepancies in some cases. The transitions from the ground states of many nuclei in this mass region are already rather fast, and the excitation energies of other states are relatively high, so that the differences in the adopted ft values do not cause significant changes in the total effective decay rates.

In addition, the transitions from some isomeric states, which can drastically change the effective rates are already experimentally known. On the other hand, the discrepancy is comparatively large for heavier nuclei. As the transitions from the ground states of these nuclei are retarded and as there are many low-lying excited states, the influence of the ft values for unknown transitions is more pronounced. Further, the contribution of bound-state β^--decays becomes larger because of smaller Q-values compared to intermediate mass nuclei.

With respect to the total effective rates for electron capture and β^+-decay, the discrepancy arises from the difference in the method of calculation as well as from the adopted ft values. However, the exact reason for unexpectedly large discrepancies for some nuclei remains unclear.

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References

1. E.M. Burbidge, G.R. Burbidge, W.A. Fowler, and F. Hoyle, Rev. Mod. Phys. **29**, 547 (1957)
2. R.A. Ward, M.J. Newman, and D.D. Clayton, Astrophys. J. Suppl. **31**, 33 (1976)
3. H. Beer, F. Käppeler, K. Yokoi, and K. Takahashi, Astrophys. J. **278**, 388 (1984)
4. G. Walter et al., KfK-Report 3652, Kernforschungszentrum Karlsruhe, 1984
5. R.R. Winters et al., KfK-Report 3827, Kernforschungszentrum Karlsruhe, 1984
6. K. Cosner, I. Iben, Jr., and J.W. Truran, Astrophys. J. (Letters) **238**, L91 (1980)
7. M.J. Newman, Master's thesis, Rice University, 1973
8. J.H. Conrad, Ph.D. thesis, University of Heidelberg, 1976
9. K. Cosner and J.W. Truran, Ap. Space Sci. **78**, 85 (1981)
10. K. Takahashi, and K. Yokoi, Nucl. Phys. **A404**, 578 (1983)
11. K. Yokoi, K. Takahashi, and M. Arnould, Astron. Astrophys. **117**, 65 (1983)
12. K. Yokoi, K. Takahashi, and M. Arnould, submitted to Astron. Astrophys.
13. K. Yokoi, and K. Takahashi, Nature **305**, 198 (1983)
14. M. Arnould, K. Takahashi, and K. Yokoi, Astron. Astrophys. **137**, 51 (1984)
15. D.A. Liberman, D.T. Cromer, and J.T. Waber, Comp. Phys. Commun. **2**, 107 (1971)
16. R.A. Ward, Astrophys. J. **216**, 540 (1977)
17. R.A. Ward, and W.A. Fowler, Astrophys. J. **238**, 266 (1980)
18. C.M. Lederer, and V.S. Shirley, Table of Isotopes (New York: Wiley), 1978
19. A.G.W. Cameron, Astrophys. J. **130**, 452 (1959)
20. E.K. Lin, Phys. Rev. **139**, B340 (1965)
21. L.A. Montestruque et al., Nucl. Phys. **A305**, 29 (1978)
22. B. Singh and D.A. Viggars, Nucl. Data Sheets **37**, 393 (1982)

23. C.V.K. Baba, G.T. Ewan, and J.F. Suårez, Nucl. Phys. **43**, 264 (1963)

24. H. Beer, G. Walter, R.L. Macklin, and P.J. Patchett, Phys. Rev. **C30**, 464 (1984)

25. J. Kern et al., Nucl. Phys. **A221**, 333 (1974)

26. K. Kawade et al., Nucl. Phys. **A279**, 269 (1977)

27. O. Nathan and S.G. Nilsson, in Alpha-, Beta-, and Gamma-Ray Spectroscopy ed. K. Siegbahn (North-Holland, Amsterdam, 1965), Chap. X

28. C. Gustafson, I.L. Lamm, B. Nilsson, and S.G. Nilsson, Arkiv Fys. **36**, 613 (1967)

29. G. Alaga, K. Alder, A. Bohr, and B.R. Mottelson, Mat. Fys. Medd. Dan. Vid. Selsk. **29**, no. 9 (1955)

30. H. Beer, F. Käppeler, K. Wisshak, and R.A. Ward, Astrophys. J. Suppl. **46**, 295 (1981)

31. C.J. Gallagher and V.G. Soloviev, Mat. Fys. Skr. Dan. Vid. Selsk. **2**, no. 2 (1962)

32. R.A. Dewberry et al., Phys. Rev. **C24**, 1643 (1981)

33. E.B. Norman and D.N. Schramm, Nature **304**, 515 (1983)

Explanation of Tables

Table I. Total Effective Rates for β^--Decay

NUCLEUS	Parent nucleus
59 Fe	Mass number and element symbol
NE	Electron number density n_e in 10^{26} cm^{-3}. For example NE=3 means $n_e=3\times10^{26}$ cm^{-3}.
T8	Temperature T in 10^8 K. For example, T8=3 means $T=3\times10^8$ K.

This table gives the total effective β^--decay rates in sec^{-1}. The values in parenthese represent the contributions of the bound-state β^--decays in percent. The rates without n_e dependence do not include the contributions of the bound-state β^--decays, as they are small ($\lesssim$20 percent at maximum).

Table II. Total Effective Rates for Electron Captures and β^+-Decay

This table gives the total effective rates for the bound and continuum electron captures and the β^+-decay in sec^{-1}. Symbols used are identical to those in Table I.

Table III. Contributions of Electron Captures to the Total Effective Rates

B	Contribution of the bound-electron captures in percent
C	Contribution of the continuum-electron captures in percent

This table gives the contributions of bound and continuum electron captures. The contribution of the β^{+}-decay (in percent) can be estimated by 100-B-C.

Table I

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
59 Fe		1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.9E-07
60 Fe		7.3E-14	7.3E-14	7.3E-14	7.3E-14	9.7E-14
60 Co		5.6E-09	4.5E-08	1.3E-07	2.1E-07	2.9E-07
61 Co		1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
63 Ni	3	4.6E-10(56)	6.3E-10(52)	1.7E-09(36)	4.4E-09(29)	8.3E-09(27)
	10	3.7E-10(47)	6.0E-10(50)	1.7E-09(35)	4.4E-09(29)	8.2E-09(27)
	30	3.1E-10(43)	5.4E-10(48)	1.6E-09(34)	4.2E-09(27)	8.0E-09(25)
65 Ni		7.6E-05	7.6E-05	7.7E-05	7.7E-05	7.7E-05
66 Ni		3.5E-06	3.5E-06	3.5E-06	3.5E-06	3.5E-06
64 Cu		6.1E-06	6.1E-06	6.0E-06	6.0E-06	5.8E-06
66 Cu		2.3E-03	2.3E-03	2.3E-03	2.3E-03	2.2E-03
67 Cu		3.1E-06	3.1E-06	3.1E-06	3.1E-06	3.1E-06
69 Zn		2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04
72 Zn		4.1E-06	4.1E-06	4.1E-06	4.1E-06	4.1E-06
70 Ga		5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04
72 Ga		1.6E-05	2.0E-05	7.1E-05	2.5E-04	5.9E-04
73 Ga		4.0E-05	4.0E-05	4.0E-05	4.1E-05	4.3E-05
75 Ge		1.4E-04	1.4E-04	1.4E-04	1.3E-04	1.2E-04
77 Ge		1.7E-05	1.7E-05	2.3E-05	4.5E-05	8.8E-05
78 Ge		1.3E-04	1.3E-04	1.3E-04	1.3E-04	1.3E-04
76 As		4.2E-05	4.9E-04	1.2E-03	1.9E-03	2.4E-03
77 As		5.0E-06	5.0E-06	5.0E-06	5.0E-06	5.0E-06
78 As		1.3E-04	1.3E-04	1.3E-04	1.5E-04	2.3E-04
79 Se	3	3.8E-12(22)	9.9E-10(27)	6.3E-09(29)	1.6E-08(29)	2.6E-08(29)
	10	3.5E-12(15)	9.6E-10(26)	6.2E-09(28)	1.5E-08(28)	2.6E-08(28)
	30	3.3E-12(13)	8.9E-10(21)	5.9E-09(25)	1.5E-08(27)	2.6E-08(28)
80 Br		5.9E-04	4.9E-04	3.9E-04	3.1E-04	2.6E-04
82 Br		5.7E-06	1.9E-05	5.9E-05	1.1E-04	1.6E-04
83 Br		8.1E-05	8.1E-05	8.1E-05	8.1E-05	8.1E-05
85 Kr		2.1E-09	2.1E-09	2.1E-09	3.0E-09	7.8E-09
87 Kr		1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04
88 Kr		6.8E-05	6.8E-05	6.8E-05	6.8E-05	6.8E-05
86 Rb		4.2E-07	4.2E-07	4.2E-07	4.2E-07	4.2E-07
87 Rb	3	5.0E-19(21)	7.4E-19(23)	4.8E-16(9)	2.4E-14(9)	2.5E-13(9)
	10	4.5E-19(13)	7.2E-19(21)	4.8E-16(9)	2.4E-14(9)	2.5E-13(9)
	30	4.5E-19(16)	6.7E-19(16)	4.7E-16(7)	2.3E-14(8)	2.5E-13(9)
88 Rb		6.2E-04	5.2E-04	4.7E-04	4.3E-04	4.1E-04

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
89 Sr		1.6E-07	1.6E-07	1.6E-07	1.6E-07	1.6E-07
90 Sr		7.6E-10	7.6E-10	7.6E-10	7.6E-10	7.6E-10
91 Sr		2.0E-05	2.0E-05	2.0E-05	2.0E-05	2.0E-05
92 Sr		7.1E-05	7.1E-05	7.1E-05	7.1E-05	7.1E-05
90 Y		3.0E-06	3.0E-06	3.0E-06	3.0E-06	3.0E-06
91 Y		1.4E-07	1.4E-07	1.4E-07	1.4E-07	1.4E-07
92 Y		5.4E-05	5.4E-05	5.4E-05	5.4E-05	5.4E-05
93 Y		1.9E-05	1.9E-05	1.9E-05	1.9E-05	1.9E-05
93 Zr	3	1.9E-14(36)	2.2E-14(49)	5.4E-14(36)	4.4E-13(28)	2.0E-12(28)
	10	1.6E-14(24)	2.1E-14(45)	5.2E-14(34)	4.3E-13(27)	2.0E-12(27)
	30	1.3E-14(17)	1.7E-14(34)	4.9E-14(31)	4.2E-13(26)	1.9E-12(26)
95 Zr		1.3E-07	1.3E-07	1.3E-07	1.3E-07	1.3E-07
97 Zr		1.1E-05	1.1E-05	1.1E-05	1.1E-05	1.1E-05
94 Nb		4.3E-08	4.4E-07	8.5E-07	1.1E-06	1.3E-06
95 Nb		2.3E-07	2.3E-07	2.3E-07	2.3E-07	2.3E-07
96 Nb		8.2E-06	7.8E-06	7.7E-06	8.5E-06	1.0E-05
97 Nb		1.6E-04	1.6E-04	1.6E-04	1.6E-04	1.6E 04
99 Mo		2.9E-06	3.1E-06	4.4E-06	1.0E-05	2.5E-05
98 Tc		4.4E-09	1.4E-08	2.0E-08	2.8E-08	3.6E-08
99 Tc	3	2.1E-13(17)	3.1E-10(22)	4.9E-09(24)	2.0E-08(25)	4.6E-08(25)
	10	1.9E-13(10)	3.0E-10(20)	4.8E-09(23)	2.0E-08(24)	4.5E-08(24)
	30	1.8E-13(5)	2.7E-10(14)	4.7E-09(20)	1.9E-08(22)	4.5E-08(24)
103 Ru		4.4E-06	4.8E-06	4.9E-06	4.9E-06	5.0E-06
105 Ru		7.2E-05	1.2E-04	1.4E-04	1.5E-04	1.5E-04
106 Ru	3	9.8E-08(86)	1.9E-07(93)	2.0E-07(94)	2.1E-07(94)	2.2E-07(92)
	10	4.8E-08(70)	1.6E-07(92)	1.9E-07(93)	2.0E-07(93)	2.1E-07(92)
	30	2.2E-08(44)	9.8E-08(87)	1.5E-07(92)	1.7E-07(92)	1.9E-07(91)
104 Rh		1.6E-02	1.5E-02	1.3E-02	1.0E-02	8.7E-03
105 Rh		5.4E-06	5.4E-06	5.4E-06	5.4E-06	5.3E-06
106 Rh		2.3E-02	2.3E-02	2.3E-02	2.2E-02	2.0E-02
107 Pd	3	6.3E-15(53)	1.3E-12(58)	3.1E-11(51)	4.1E-10(46)	2.3E-09(46)
	10	5.1E-15(41)	1.1E-12(53)	3.0E-11(48)	4.0E-10(45)	2.2E-09(45)
	30	3.9E-15(31)	9.1E-13(42)	2.7E-11(44)	3.8E-10(43)	2.2E-09(43)
109 Pd		1.4E-05	1.4E-05	1.4E-05	1.4E-05	1.4E-05
108 Ag		4.9E-03	4.8E-03	4.2E-03	3.5E-03	2.8E-03
110 Ag		1.2E-02	1.1E-02	1.1E-02	1.0E-02	9.2E-03
111 Ag		1.2E-06	4.5E-06	1.0E-05	1.4E-05	1.7E-05
112 Ag		1.0E-02	2.7E-02	3.5E-02	4.1E-02	4.4E-02
113 Ag		8.7E-05	5.2E-04	8.9E-04	1.1E-03	1.2E-03

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
113 Cd	3	4.7E-22(7)	3.1E-15(19)	4.0E-12(14)	3.0E-10(13)	4.1E-09(13)
	10	4.6E-22(4)	3.0E-15(16)	3.9E-12(13)	3.0E-10(13)	4.1E-09(13)
	30	4.5E-22(3)	2.8E-15(11)	3.8E-12(11)	2.9E-10(12)	4.1E-09(12)
115 Cd		3.6E-06	3.6E-06	3.6E-06	3.6E-06	3.7E-06
117 Cd		8.0E-05	8.0E-05	7.9E-05	7.8E-05	7.6E-05
114 In		9.5E-03	9.5E-03	9.4E-03	9.3E-03	8.9E-03
115 In		5.5E-23	1.4E-15	9.6E-13	2.5E-11	1.8E-10
116 In		4.9E-02	4.9E-02	4.8E-02	4.5E-02	4.0E-02
117 In		2.8E-04	2.8E-04	2.8E-04	2.8E-04	2.8E-04
121 Sn		2.9E-06	2.3E-06	2.1E-06	2.0E-06	1.9E-06
123 Sn		5.4E-06	2.1E-05	3.3E-05	4.0E-05	4.6E-05
125 Sn		1.7E-05	7.8E-05	1.3E-04	1.6E-04	1.8E-04
126 Sn	3	2.7E-13(19)	3.8E-13(43)	4.0E-13(47)	4.1E-13(47)	4.1E-13(47)
	10	2.5E-13(12)	3.4E-13(37)	3.8E-13(44)	4.0E-13(46)	4.0E-13(47)
	30	2.3E-13(8)	2.9E-13(26)	3.5E-13(39)	3.8E-13(44)	3.9E-13(45)
127 Sn		5.2E-04	6.4E-04	6.8E-04	7.0E-04	7.2E-04
122 Sb		2.9E-06	3.8E-06	1.1E-05	2.4E-05	3.7E-05
124 Sb		4.7E-04	6.8E-04	7.6E-04	8.0E-04	8.2E-04
125 Sb		8.1E-09	8.1E-09	8.3E-09	1.2E-08	3.5E-08
126 Sb		4.7E-05	1.2E-04	1.9E-04	2.7E-04	3.5E-04
127 Sb		2.1E-06	2.1E-06	2.1E-06	2.1E-06	2.1E-06
128 Sb		8.9E-05	2.2E-04	3.2E-04	4.2E-04	5.0E-04
129 Sb		4.4E-05	4.4E-05	4.4E-05	4.4E-05	4.4E-05
127 Te		2.1E-05	2.0E-05	1.8E-05	1.5E-05	1.3E-05
129 Te		1.7E-04	1.7E-04	1.6E-04	1.5E-04	1.3E-04
126 I		3.3E-07	1.4E-06	3.6E-06	5.7E-06	7.6E-06
128 I		4.1E-04	3.3E-04	2.7E-04	2.2E-04	1.9E-04
129 I	3	3.3E-09(25)	2.6E-08(59)	4.4E-08(62)	5.5E-08(63)	6.3E-08(63)
	10	2.9E-09(16)	2.1E-08(50)	4.1E-08(60)	5.3E-08(62)	6.2E-08(63)
	30	2.7E-09(13)	1.6E-08(36)	3.6E-08(54)	4.9E-08(59)	5.9E-08(61)
130 I		1.6E-05	2.1E-05	2.9E-05	3.6E-05	4.1E-05
131 I		1.0E-06	1.0E-06	1.3E-06	2.3E-06	4.0E-06
132 I		9.8E-05	1.3E-04	1.4E-04	1.6E-04	1.8E-04
133 I		9.2E-06	9.2E-06	9.2E-06	9.2E-06	9.3E-06
134 I		2.2E-04	2.2E-04	2.2E-04	2.3E-04	2.4E-04
135 I		2.9E-05	2.9E-05	2.9E-05	2.9E-05	2.9E-05
133 Xe	3	1.7E-06(10)	2.3E-06(35)	2.4E-06(39)	2.5E-06(40)	2.5E-06(40)
	10	1.6E-06(6)	2.1E-06(27)	2.3E-06(36)	2.4E-06(39)	2.4E-06(39)
	30	1.6E-06(6)	1.8E-06(17)	2.2E-06(31)	2.3E-06(36)	2.3E-06(37)
135 Xe		2.1E-05	2.1E-05	2.1E-05	2.1E-05	2.1E-05
134 Cs		3.3E-08	6.3E-07	2.1E-06	4.8E-06	8.9E-06
135 Cs	3	8.8E-15(18)	6.6E-13(28)	8.5E-11(30)	9.6E-10(31)	4.2E-09(32)
	10	8.0E-15(11)	6.1E-13(21)	8.2E-11(28)	9.5E-10(30)	4.1E-09(30)
	30	7.8E-15(12)	5.5E-13(13)	7.7E-11(23)	9.2E-10(28)	4.0E-09(29)

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
136 Cs		6.1E-07	6.1E-07	6.1E-07	6.1E-07	6.1E-07
137 Cs		7.3E-10	7.3E-10	7.4E-10	1.3E-09	8.8E-09
139 Ba		1.4E-04	1.4E-04	1.4E-04	1.4E-04	1.4E-04
140 Ba		6.3E-07	6.3E-07	6.3E-07	6.3E-07	6.3E-07
138 La		2.7E-11	2.0E-09	1.1E-08	6.1E-08	2.5E-07
140 La		4.9E-06	5.5E-06	6.0E-06	6.2E-06	6.3E-06
141 La		4.9E-05	4.9E-05	4.9E-05	4.9E-05	4.9E-05
141 Ce		2.5E-07	2.5E-07	2.5E-07	2.5E-07	2.5E-07
143 Ce		5.5E-06	5.1E-06	5.0E-06	4.9E-06	4.8E-06
144 Ce	3	3.2E-08(12)	5.1E-08(46)	5.5E-08(51)	5.7E-08(52)	5.8E-08(53)
	10	3.1E-08(8)	4.2E-08(34)	5.2E-08(48)	5.5E-08(51)	5.6E-08(51)
	30	3.0E-08(9)	3.5E-08(22)	4.6E-08(41)	5.0E-08(46)	5.3E-08(49)
142 Pr		3.8E-06	3.0E-06	2.6E-06	2.3E-06	2.1E-06
143 Pr		5.9E-07	6.0E-07	6.2E-07	6.4E-07	6.6E-07
147 Nd		7.3E-07	7.3E-07	7.3E-07	7.4E-07	7.4E-07
149 Nd		1.1E-04	1.1E-04	1.1E-04	1.0E-04	1.0E-04
150 Nd	3	4.1E-19(100)	2.5E-14(100)	3.9E-13(100)	1.4E-12(100)	2.6E-12(100)
	10	2.6E-20(100)	1.3E-14(100)	3.2E-13(100)	1.2E-12(100)	2.4E-12(100)
	30	2.0E-21(100)	4.0E-15(100)	2.0E-13(100)	9.0E-13(100)	2.0E-12(100)
147 Pm	3	9.7E-09(15)	1.7E-08(55)	2.0E-08(61)	2.0E-08(63)	2.0E-08(64)
	10	9.2E-09(11)	1.3E-08(41)	1.8E-08(58)	1.9E-08(61)	1.9E-08(62)
	30	9.0E-09(12)	1.1E-08(26)	1.6E-08(53)	1.7E-08(56)	1.8E-08(60)
148 Pm		1.5E-06	1.5E-06	1.5E-06	1.5E-06	1.5E-06
149 Pm		3.6E-06	3.6E-06	3.6E-06	3.6E-06	3.8E-06
151 Sm	3	2.9E-10(44)	2.4E-09(82)	8.5E-09(77)	1.8E-08(74)	2.9E-08(71)
	10	2.4E-10(33)	1.5E-09(70)	7.5E-09(74)	1.7E-08(72)	2.8E-08(70)
	30	2.3E-10(36)	9.1E-10(51)	6.0E-09(68)	1.5E-08(68)	2.5E-08(67)
153 Sm		4.7E-06	6.0E-06	7.0E-06	8.0E-06	8.9E-06
152 Eu		1.0E-07	9.8E-06	4.2E-05	7.6E-05	1.0E-04
154 Eu		6.2E-09	2.1E-07	7.5E-07	1.2E-06	1.5E-06
155 Eu	3	5.4E-09(22)	1.8E-08(61)	5.6E-08(55)	1.3E-07(52)	2.1E-07(51)
	10	5.0E-09(16)	1.3E-08(45)	5.1E-08(51)	1.2E-07(50)	2.0E-07(50)
	30	4.9E-09(19)	9.8E-09(30)	4.3E-08(42)	1.1E-07(45)	1.9E-07(47)
156 Eu		1.3E-04	3.2E-04	3.7E-04	3.8E-04	3.7E-04
157 Eu		1.3E-05	1.3E-05	1.2E-05	1.3E-05	1.6E-05
157 Gd	3	1.0E-14(100)	2.9E-11(100)	1.2E-10(100)	2.0E-10(100)	2.7E-10(100)
	10	8.4E-16(100)	1.1E-11(100)	9.8E-11(100)	1.8E-10(100)	2.5E-10(100)
	30	5.1E-17(100)	3.0E-12(100)	4.9E-11(100)	1.3E-10(100)	2.0E-10(100)
159 Gd		1.0E-05	1.0E-05	9.9E-06	9.6E-06	9.3E-06

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
160 Gd	3	8.3E-21(99)	1.2E-15(90)	1.4E-13(92)	1.4E-12(93)	4.9E-12(93)
	10	4.6E-22(84)	5.8E-16(80)	1.3E-13(91)	1.2E-12(92)	4.6E-12(93)
	30	1.3E-22(47)	3.1E-16(63)	7.6E-14(85)	1.0E-12(90)	4.0E-12(92)
158 Tb		3.5E-11	5.7E-09	4.8E-08	1.3E-07	2.2E-07
160 Tb		2.5E-07	5.5E-06	1.8E-05	3.0E-05	4.2E-05
161 Tb	3	1.3E-06(6)	1.6E-06(26)	1.7E-06(33)	1.7E-06(34)	1.8E-06(34)
	10	1.3E-06(4)	1.4E-06(15)	1.6E-06(29)	1.7E-06(32)	1.7E-06(32)
	30	1.3E-06(5)	1.3E-06(9)	1.4E-06(19)	1.6E-06(27)	1.6E-06(30)
163 Dy	3	8.2E-10(99)	1.1E-07(100)	1.8E-07(99)	2.1E-07(99)	2.3E-07(98)
	10	4.2E-11(89)	4.2E-08(99)	1.4E-07(99)	1.8E-07(99)	2.1E-07(98)
	30	9.9E-12(56)	1.1E-08(97)	6.7E-08(98)	1.4E-07(98)	1.8E-07(98)
165 Dy		8.3E-05	8.3E-05	8.3E-05	8.3E-05	8.3E-05
164 Ho		1.7E-04	1.5E-04	1.4E-04	1.3E-04	1.1E-04
166 Ho		8.1E-07	1.8E-06	4.5E-06	7.7E-06	1.0E-05
167 Ho		6.2E-05	6.2E-05	6.2E-05	6.2E-05	6.2E-05
169 Er	3	9.9E-07(10)	1.3E-06(36)	1.3E-06(49)	1.1E-06(52)	9.0E-07(52)
	10	9.6E-07(7)	1.0E-06(22)	1.1E-06(43)	1.0E-06(49)	8.7E-07(51)
	30	9.6E-07(9)	9.6E-07(16)	9.2E-07(29)	9.1E-07(42)	8.1E-07(47)
171 Er		2.6E-05	2.6E-05	2.6E-05	2.7E-05	2.8E-05
170 Tm		6.2E-08	6.0E-08	6.8E-08	1.1E-07	2.0E-07
171 Tm	3	1.1E-08(39)	4.1E-08(87)	6.6E-08(92)	7.0E-08(93)	6.7E-08(93)
	10	9.3E-09(31)	2.1E-08(72)	5.1E-08(90)	6.2E-08(92)	6.3E-08(92)
	30	9.0E-09(34)	1.5E-08(62)	2.7E-08(81)	4.7E-08(90)	5.4E-08(91)
172 Tm		3.0E-06	3.0E-06	3.1E-06	3.1E-06	3.1E-06
173 Tm		2.2E-05	2.2E-05	2.2E-05	2.1E-05	2.0E-05
175 Yb	3	2.4E-06(12)	4.1E-06(50)	5.9E-06(66)	6.3E-06(68)	6.5E-06(67)
	10	2.3E-06(9)	2.9E-06(30)	4.8E-06(58)	5.8E-06(65)	6.2E-06(66)
	30	2.3E-06(10)	2.6E-06(21)	3.4E-06(40)	4.8E-06(57)	5.6E-06(62)
177 Yb		1.0E-04	1.1E-04	1.4E-04	1.9E-04	2.6E-04
176 Lu		4.2E-12	6.9E-09	9.6E-08	4.2E-07	1.1E-06
177 Lu	3	1.3E-06(8)	1.8E-06(31)	2.5E-06(45)	3.7E-06(44)	5.5E-06(41)
	10	1.3E-06(6)	1.5E-06(18)	2.2E-06(37)	3.5E-06(41)	5.4E-06(40)
	30	1.3E-06(8)	1.4E-06(12)	1.8E-06(23)	3.2E-06(34)	5.1E-06(36)
179 Hf	3	4.9E-18(55)	6.3E-12(92)	8.0E-10(97)	7.0E-09(97)	2.4E-08(97)
	10	3.8E-18(43)	2.8E-12(82)	5.7E-10(95)	6.0E-09(97)	2.2E-08(97)
	30	3.7E-18(46)	1.3E-12(61)	2.6E-10(88)	4.3E-09(95)	1.8E-08(96)
181 Hf		2.5E-07	2.5E-06	6.4E-06	9.0E-06	1.1E-05
182 Hf	3	5.4E-13(13)	2.2E-10(42)	1.9E-09(60)	4.6E-09(62)	7.4E-09(62)
	10	5.2E-13(9)	1.8E-10(26)	1.6E-09(51)	4.3E-09(59)	7.1E-09(60)
	30	5.2E-13(12)	1.5E-10(15)	1.2E-09(34)	3.6E-09(51)	6.4E-09(56)
180 Ta		4.2E-06	3.7E-06	3.0E-06	2.4E-06	1.9E-06
182 Ta		1.5E-07	2.4E-07	2.7E-07	2.8E-07	2.7E-07

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
183 Ta		1.6E-06	1.6E-06	1.8E-06	2.0E-06	2.1E-06
184 Ta		2.2E-05	2.2E-05	2.1E-05	2.1E-05	2.1E-05
185 W	3	1.2E-07(8)	1.3E-07(25)	1.7E-07(43)	1.9E-07(46)	2.0E-07(46)
	10	1.2E-07(6)	1.2E-07(15)	1.5E-07(34)	1.8E-07(42)	2.0E-07(44)
	30	1.2E-07(7)	1.1E-07(8)	1.2E-07(20)	1.6E-07(34)	1.8E-07(40)
187 W		8.1E-06	8.2E-06	8.8E-06	9.5E-06	1.0E-05
188 W	3	1.2E-07(10)	1.6E-07(32)	2.3E-07(52)	2.5E-07(54)	2.8E-07(54)
	10	1.2E-07(7)	1.3E-07(20)	1.9E-07(43)	2.4E-07(51)	2.7E-07(52)
	30	1.2E-07(10)	1.2E-07(11)	1.5E-07(26)	2.0E-07(43)	2.5E-07(48)
186 Re		2.0E-06	2.0E-06	2.1E-06	2.2E-06	2.3E-06
187 Re	3	2.8E-13(100)	4.2E-10(100)	1.6E-09(98)	4.7E-09(95)	1.3E-08(94)
	10	6.0E-15(99)	1.0E-10(99)	1.0E-09(97)	4.0E-09(95)	1.2E-08(94)
	30	4.3E-16(90)	8.1E-12(92)	3.7E-10(91)	2.7E-09(92)	9.5E-09(92)
188 Re		1.1E-05	1.2E-05	1.2E-05	1.3E-05	1.4E-05
189 Re		7.9E-06	8.0E-06	8.4E-06	9.6E-06	1.1E-05
191 Os	3	6.5E-07(30)	1.4E-06(68)	2.9E-06(86)	3.2E-06(88)	3.2E-06(88)
	10	5.9E-07(22)	8.1E-07(46)	2.0E-06(80)	2.7E-06(86)	2.9E-06(87)
	30	5.9E-07(27)	6.2E-07(31)	1.1E-06(61)	2.0E-06(80)	2.5E-06(85)
193 Os		6.3E-06	6.2E-06	5.9E-06	5.5E-06	5.2E-06
192 Ir		1.0E-07	1.2E-07	1.5E-07	1.7E-07	1.9E-07
193 Ir	3	1.4E-14(99)	4.1E-11(99)	3.3E-10(99)	8.2E-10(98)	1.4E-09(98)
	10	2.7E-15(96)	7.1E-12(95)	1.9E-10(97)	6.6E-10(97)	1.3E-09(97)
	30	1.2E-15(92)	1.2E-12(73)	5.8E-11(92)	4.1E-10(96)	1.0E-09(96)
194 Ir		1.0E-05	1.3E-05	1.6E-05	1.9E-05	2.0E-05
195 Ir		7.7E-05	7.6E-05	7.3E-05	7.0E-05	6.7E-05
195 Pt	3	3.9E-23(100)	6.6E-15(100)	1.7E-12(100)	1.7E-11(99)	5.9E-11(98)
	10	1.5E-23(100)	1.2E-15(100)	9.6E-13(100)	1.3E-11(99)	5.2E-11(98)
	30	5.5E-24(100)	1.0E-16(98)	2.7E-13(99)	7.9E-12(98)	4.0E-11(97)
197 Pt		1.1E-05	1.1E-05	1.2E-05	1.3E-05	1.3E-05
196 Au	3	1.0E-07(16)	1.3E-07(39)	2.2E-07(67)	2.3E-07(71)	2.2E-07(73)
	10	9.5E-08(11)	1.1E-07(23)	1.6E-07(54)	2.0E-07(67)	2.0E-07(71)
	30	9.5E-08(14)	9.6E-08(16)	1.1E-07(33)	1.5E-07(57)	1.7E-07(66)
198 Au		3.1E-06	6.1E-06	1.2E-05	1.8E-05	2.3E-05
199 Au	3	2.8E-06(14)	3.6E-06(35)	6.0E-06(62)	6.8E-06(66)	7.1E-06(67)
	10	2.6E-06(10)	3.0E-06(20)	4.6E-06(49)	6.0E-06(62)	6.7E-06(65)
	30	2.7E-06(12)	2.7E-06(14)	3.3E-06(29)	4.8E-06(51)	5.8E-06(60)
203 Hg	3	8.6E-06(7)	1.2E-05(18)	1.7E-05(41)	1.8E-05(46)	1.9E-05(48)
	10	8.4E-06(5)	1.1E-05(11)	1.4E-05(29)	1.7E-05(42)	1.8E-05(46)
	30	8.4E-06(5)	1.1E-05(8)	1.2E-05(15)	1.5E-05(31)	1.7E-05(40)
204 Tl		5.7E-09	7.8E-08	1.1E-06	4.4E-06	9.9E-06

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
205 Tl	3	1.5E-12(100)	1.5E-08(100)	8.7E-08(100)	1.1E-07(100)	1.3E-07(99)
	10	1.4E-14(100)	2.1E-09(100)	4.0E-08(100)	8.3E-08(99)	1.1E-07(98)
	30	6.5E-16(98)	1.3E-10(99)	8.8E-09(99)	4.3E-08(99)	7.6E-08(98)
209 Pb		5.9E-05	5.9E-05	5.9E-05	5.9E-05	5.9E-05
210 Pb	3	6.3E-09(97)	8.4E-08(100)	4.9E-07(100)	6.4E-07(100)	6.9E-07(100)
	10	2.9E-09(93)	1.8E-08(99)	2.4E-07(100)	5.0E-07(100)	6.1E-07(100)
	30	1.0E-09(82)	5.0E-09(97)	5.8E-08(100)	2.7E-07(100)	4.5E-07(100)
210 Bi		2.1E-06	9.1E-06	2.0E-05	2.9E-05	3.7E-05

Table II

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
59 Ni	3	4.9E-14	1.7E-14	9.5E-13	2.3E-11	1.6E-10
	10	1.3E-13	4.9E-14	1.6E-12	3.6E-11	2.3E-10
	30	2.3E-13	1.2E-13	2.8E-12	7.0E-11	4.4E-10
64 Cu	3	3.5E-06	2.7E-06	2.6E-06	2.5E-06	2.4E-06
	10	5.5E-06	3.4E-06	3.0E-06	2.8E-06	2.6E-06
	30	7.4E-06	4.9E-06	4.0E-06	3.6E-06	3.3E-06
65 Zn	3	4.9E-09	4.5E-09	8.5E-09	1.5E-08	2.3E-08
	10	1.7E-08	1.1E-08	1.6E-08	2.5E-08	3.5E-08
	30	2.6E-08	2.4E-08	3.7E-08	5.3E-08	7.0E-08
70 Ga	3	2.3E-07	6.5E-08	3.6E-08	2.6E-08	2.1E-08
	10	6.3E-07	2.0E-07	1.2E-07	8.4E-08	6.4E-08
	30	9.6E-07	4.9E-07	3.2E-07	2.4E-07	2.0E-07
71 Ge	3	1.4E-07	3.8E-08	2.2E-08	1.6E-08	1.3E-08
	10	3.7E-07	1.2E-07	6.9E-08	5.1E-08	4.1E-08
	30	5.5E-07	2.1E-07	2.0E-07	1.5E-07	1.2E-07
76 As	3	2.2E-09	6.1E-09	7.4E-09	6.8E-09	6.9E-09
	10	5.3E-09	1.8E-08	2.3E-08	2.1E-08	2.3E-08
	30	7.5E-09	4.2E-08	6.5E-08	6.9E-08	6.6E-08
75 Se	3	1.8E-08	4.0E-09	2.5E-09	2.2E-09	2.3E-09
	10	4.1E-08	1.2E-08	7.8E-09	7.2E-09	7.5E-09
	30	5.6E-08	3.0E-08	2.2E-08	2.1E-08	2.2E-08
79 Br	3	4.1E-22	3.2E-17	2.0E-15	2.2E-14	1.1E-13
	10	9.6E-22	9.9E-17	6.7E-15	7.3E-14	3.6E-13
	30	1.5E-21	2.7E-16	2.0E-14	2.2E-13	1.1E-12
80 Br	3	2.8E-05	1.5E-05	1.1E-05	8.7E-06	7.1E-06
	10	4.4E-05	2.0E-05	1.3E-05	9.8E-06	7.7E-06
	30	5.3E-05	3.0E-05	1.8E-05	1.2E-05	9.5E-06
82 Br	3	3.0E-13	6.2E-12	1.4E-11	2.2E-11	2.8E-11
	10	6.9E-13	1.9E-11	4.6E-11	7.0E-11	9.2E-11
	30	9.6E-13	4.8E-11	1.3E-10	2.0E-10	2.7E-10
79 Kr	3	1.8E-06	6.8E-07	5.0E-07	4.1E-07	3.4E-07
	10	3.5E-06	1.3E-06	8.0E-07	5.9E-07	4.6E-07
	30	4.4E-06	2.6E-06	1.5E-06	1.1E-06	7.8E-07
81 Kr	3	3.5E-14	2.9E-13	5.0E-12	1.9E-11	4.2E-11
	10	7.8E-14	8.6E-13	1.6E-11	6.3E-11	1.4E-10
	30	1.1E-13	2.3E-12	4.4E-11	1.8E-10	4.0E-10
86 Rb	3	7.5E-12	1.5E-12	7.0E-13	5.9E-13	7.6E-13
	10	1.6E-11	4.6E-12	2.1E-12	1.9E-12	2.5E-12
	30	1.7E-11	1.2E-11	7.0E-12	5.5E-12	7.3E-12
85 Sr	3	4.7E-08	8.9E-09	4.2E-09	2.8E-09	2.3E-09
	10	9.5E-08	2.6E-08	1.3E-08	9.0E-09	7.6E-09
	30	1.1E-07	6.7E-08	3.6E-08	2.6E-08	2.2E-08
87 Sr	3	3.8E-28	4.8E-19	4.6E-16	1.5E-14	1.3E-13
	10	7.8E-28	1.4E-18	1.5E-15	4.9E-14	4.1E-13
	30	9.5E-28	3.8E-18	4.1E-15	1.4E-13	1.2E-12

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
94 Nb	3	2.5E-14	2.5E-13	6.4E-13	1.1E-12	1.6E-12
	10	7.8E-14	8.2E-13	2.1E-12	3.7E-12	5.3E-12
	30	2.1E-13	2.4E-12	6.3E-12	1.1E-11	1.6E-11
93 Mo	3	3.0E-12	4.2E-13	2.5E-13	1.7E-13	1.5E-13
	10	5.2E-12	1.1E-12	7.9E-13	5.6E-13	4.9E-13
	30	7.1E-12	3.9E-12	2.2E-12	1.6E-12	1.4E-12
97 Tc	3	4.5E-15	1.3E-13	3.4E-12	1.6E-11	4.1E-11
	10	7.4E-15	3.3E-13	1.0E-11	5.2E-11	1.3E-10
	30	9.6E-15	8.7E-13	2.8E-11	1.4E-10	3.8E-10
98 Tc	3	6.5E-16	2.9E-13	1.7E-12	3.6E-12	5.7E-12
	10	1.0E-15	7.5E-13	4.8E-12	1.1E-11	1.6E-11
	30	1.3E-15	1.9E-12	1.2E-11	2.8E-11	4.4E-11
97 Ru	3	1.3E-06	2.1E-07	8.5E-08	5.0E-08	3.5E-08
	10	2.1E-06	5.8E-07	2.6E-07	1.6E-07	1.1E-07
	30	2.6E-06	1.4E-06	6.9E-07	4.4E-07	3.2E-07
104 Rh	3	3.5E-05	5.1E-06	1.7E-06	7.9E-07	4.5E-07
	10	5.2E-05	1.4E-05	5.1E-06	2.5E-06	1.5E-06
	30	6.3E-05	3.3E-05	1.3E-05	6.9E-06	4.1E-06
103 Pd	3	2.9E-07	4.6E-08	1.8E-08	9.9E-09	6.8E-09
	10	4.1E-07	1.3E-07	5.4E-08	3.2E-08	2.2E-08
	30	5.0E-07	2.9E-07	1.4E-07	8.7E-08	6.3E-08
107 Ag	3	7.0E-14	3.0E-12	8.4E-12	1.4E-11	1.8E-11
	10	1.1E-13	8.9E-12	2.7E-11	4.6E-11	6.2E-11
	30	1.5E-13	2.2E-11	7.7E-11	1.3E-10	1.9E-10
108 Ag	3	7.5E-05	2.0E-05	1.2E-05	8.9E-06	6.7E-06
	10	9.8E-05	3.8E-05	1.9E-05	1.2E-05	8.6E-06
	30	1.1E-04	7.1E-05	3.4E-05	2.0E-05	1.3E-05
110 Ag	3	2.1E-05	3.2E-06	1.1E-06	5.9E-07	3.3E-07
	10	2.9E-05	9.0E-06	3.5E-06	1.9E-06	1.2E-06
	30	3.4E-05	1.9E-05	8.9E-06	5.1E-06	3.4E-06
107 Cd	3	2.2E-05	3.6E-06	1.3E-06	7.3E-07	5.0E-07
	10	2.9E-05	9.7E-06	3.8E-06	2.2E-06	1.5E-06
	30	3.3E-05	2.0E-05	9.7E-06	5.9E-06	4.1E-06
109 Cd	3	1.3E-08	2.3E-09	9.8E-10	6.9E-10	6.4E-10
	10	1.8E-08	6.7E-09	3.1E-09	2.2E-09	2.1E-09
	30	2.4E-08	1.5E-08	8.3E-09	6.4E-09	6.2E-09
113 In	3	9.1E-31	1.3E-21	1.2E-18	3.9E-17	3.4E-16
	10	1.3E-30	3.7E-21	3.7E-18	1.3E-16	1.1E-15
	30	1.7E-30	8.7E-21	1.0E-17	3.7E-16	3.4E-15
114 In	3	1.2E-04	2.1E-05	8.0E-06	4.7E-06	3.3E-06
	10	1.6E-04	5.6E-05	2.2E-05	1.2E-05	8.4E-06
	30	1.8E-04	1.1E-04	5.4E-05	3.2E-05	2.2E-05
116 In	3	3.6E-06	6.0E-07	2.0E-07	1.0E-07	6.3E-08
	10	4.6E-06	1.6E-06	6.2E-07	3.3E-07	2.1E-07
	30	5.3E-06	3.4E-06	1.6E-06	9.0E-07	5.8E-07
113 Sn	3	6.6E-08	2.7E-07	3.6E-07	3.4E-07	3.0E-07
	10	8.2E-08	7.2E-07	1.1E-06	1.1E-06	9.7E-07
	30	9.3E-08	1.4E-06	2.7E-06	2.9E-06	2.7E-06

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
122 Sb	3	6.4E-08	1.6E-08	2.5E-08	4.2E-08	6.3E-08
	10	7.6E-08	4.0E-08	5.4E-08	8.1E-08	1.0E-07
	30	8.9E-08	7.8E-08	1.2E-07	1.7E-07	2.0E-07
121 Te	3	3.7E-07	7.1E-08	2.4E-08	1.4E-08	1.3E-08
	10	4.5E-07	1.9E-07	7.1E-08	4.4E-08	4.0E-08
	30	5.2E-07	3.6E-07	1.8E-07	1.2E-07	1.1E-07
123 Te	3	5.6E-17	1.5E-13	1.7E-12	7.0E-12	1.7E-11
	10	8.6E-17	4.3E-13	5.7E-12	2.3E-11	5.8E-11
	30	1.4E-16	1.0E-12	1.6E-11	6.9E-11	1.7E-10
125 I	3	9.3E-08	1.9E-08	6.3E-09	3.4E-09	2.4E-09
	10	1.1E-07	5.0E-08	1.9E-08	1.1E-08	7.9E-09
	30	1.4E-07	9.7E-08	4.9E-08	3.1E-08	1.9E-08
126 I	3	2.8E-07	1.2E-07	1.5E-07	2.1E-07	2.6E-07
	10	3.2E-07	2.5E-07	2.3E-07	2.7E-07	3.1E-07
	30	3.6E-07	4.2E-07	4.1E-07	4.2E-07	3.9E-07
128 I	3	2.1E-05	3.2E-06	7.9E-07	3.1E-07	1.5E-07
	10	2.4E-05	8.2E-06	2.3E-06	9.6E-07	4.8E-07
	30	2.7E-05	1.5E-05	5.7E-06	2.5E-06	1.0E-06
125 Xe	3	7.9E-06	1.6E-06	5.7E-07	3.6E-07	3.1E-07
	10	8.9E-06	4.0E-06	1.5E-06	8.8E-07	5.7E-07
	30	9.8E-06	7.1E-06	3.5E-06	2.1E-06	1.5E-06
127 Xe	3	1.9E-07	3.8E-08	1.4E-08	9.2E-09	7.9E-09
	10	2.1E-07	9.7E-08	4.1E-08	2.9E-08	2.1E-08
	30	2.4E-07	1.8E-07	1.0E-07	7.7E-08	6.9E-08
131 Cs	3	7.7E-07	1.6E-07	4.6E-08	2.1E-08	1.3E-08
	10	8.7E-07	4.0E-07	1.4E-07	6.8E-08	4.1E-08
	30	9.6E-07	7.1E-07	3.3E-07	1.8E-07	1.2E-07
134 Cs	3	6.1E-11	4.1E-10	9.6E-10	1.9E-09	3.0E-09
	10	6.9E-11	1.0E-09	2.8E-09	5.8E-09	8.7E-09
	30	7.6E-11	1.8E-09	6.6E-09	1.5E-08	2.4E-08
131 Ba	3	5.3E-07	1.2E-07	4.1E-08	2.5E-08	2.0E-08
	10	5.8E-07	2.9E-07	1.2E-07	7.7E-08	6.0E-08
	30	6.3E-07	4.9E-07	2.8E-07	1.5E-07	1.6E-07
133 Ba	3	4.6E-07	1.6E-07	5.2E-08	2.6E-08	1.7E-08
	10	5.1E-07	3.8E-07	1.5E-07	8.2E-08	5.4E-08
	30	5.6E-07	6.6E-07	3.6E-07	1.6E-07	1.5E-07
137 La	3	8.5E-07	3.2E-07	8.4E-08	5.3E-08	3.4E-08
	10	9.3E-07	7.6E-07	3.1E-07	1.6E-07	1.1E-07
	30	1.0E-06	1.3E-06	7.2E-07	4.0E-07	3.0E-07
138 La	3	1.5E-11	2.5E-10	3.5E-10	1.7E-09	6.6E-09
	10	1.6E-11	5.9E-10	1.1E-09	3.0E-09	9.5E-09
	30	1.8E-11	9.9E-10	2.5E-09	6.0E-09	1.7E-08
137 Ce	3	2.1E-05	5.2E-06	1.4E-06	6.7E-07	3.9E-07
	10	2.3E-05	1.2E-05	4.2E-06	2.1E-06	1.2E-06
	30	2.4E-05	1.9E-05	9.7E-06	5.2E-06	3.4E-06
139 Ce	3	5.1E-08	1.3E-08	4.2E-09	2.4E-09	1.9E-09
	10	6.0E-08	3.2E-08	1.3E-08	7.9E-09	6.1E-09
	30	7.5E-08	5.8E-08	3.3E-08	2.2E-08	1.8E-08

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
142 Pr	3	5.7E-10	1.4E-10	4.4E-11	2.5E-11	1.8E-11
	10	6.3E-10	3.1E-10	1.3E-10	6.2E-11	5.8E-11
	30	7.1E-10	5.0E-10	3.0E-10	2.1E-10	1.6E-10
145 Pm	3	1.1E-09	3.7E-10	1.2E-10	6.7E-11	4.8E-11
	10	1.3E-09	8.3E-10	3.6E-10	2.1E-10	1.5E-10
	30	1.5E-09	1.3E-09	6.8E-10	5.8E-10	4.4E-10
148 Pm	3	7.9E-10	2.3E-10	5.8E-11	2.3E-11	1.2E-11
	10	8.4E-10	5.1E-10	1.7E-10	6.9E-11	3.7E-11
	30	9.1E-10	7.5E-10	2.9E-10	1.9E-10	1.0E-10
145 Sm	3	2.0E-08	6.4E-09	1.7E-09	7.3E-10	4.2E-10
	10	2.1E-08	1.3E-08	4.8E-09	2.2E-09	1.3E-09
	30	2.3E-08	1.9E-08	9.0E-09	5.9E-09	3.6E-09
152 Eu	3	1.2E-08	3.0E-07	3.5E-07	3.0E-07	2.5E-07
	10	1.3E-08	6.0E-07	9.0E-07	7.7E-07	6.1E-07
	30	1.4E-08	8.2E-07	1.8E-06	1.9E-06	1.5E-06
154 Eu	3	1.2E-11	2.3E-10	2.1E-10	1.5E-10	1.0E-10
	10	1.3E-11	4.6E-10	5.8E-10	4.4E-10	3.1E-10
	30	1.4E-11	6.3E-10	1.2E-09	1.2E-09	8.6E-10
153 Gd	3	2.7E-08	9.5E-09	3.7E-09	2.1E-09	1.5E-09
	10	3.2E-08	2.3E-08	8.3E-09	6.4E-09	4.9E-09
	30	3.9E-08	3.4E-08	2.5E-08	1.7E-08	1.4E-08
157 Tb	3	1.0E-10	5.0E-11	3.0E-11	2.6E-11	2.9E-11
	10	1.7E-10	1.3E-10	9.0E-11	8.5E-11	9.3E-11
	30	3.0E-10	2.7E-10	2.6E-10	2.4E-10	2.7E-10
158 Tb	3	9.2E-11	3.7E-10	8.2E-10	9.2E-10	8.8E-10
	10	1.0E-10	7.7E-10	2.1E-09	2.8E-09	2.7E-09
	30	1.2E-10	1.0E-09	5.1E-09	7.1E-09	7.4E-09
160 Tb	3	1.7E-13	2.4E-12	2.3E-12	1.9E-12	1.7E-12
	10	1.8E-13	5.1E-12	6.1E-12	5.9E-12	5.4E-12
	30	2.1E-13	7.2E-12	1.6E-11	1.6E-11	1.5E-11
157 Dy	3	2.2E-05	9.1E-06	2.3E-06	8.5E-07	4.3E-07
	10	2.3E-05	1.7E-05	6.0E-06	2.6E-06	1.3E-06
	30	2.5E-05	2.2E-05	1.4E-05	6.5E-06	3.6E-06
159 Dy	3	5.2E-08	2.2E-08	6.0E-09	2.7E-09	1.7E-09
	10	5.6E-08	4.1E-08	1.6E-08	8.1E-09	5.3E-09
	30	6.1E-08	5.4E-08	3.8E-08	2.1E-08	1.5E-08
163 Ho	3	1.6E-10	3.3E-10	5.4E-10	7.8E-10	1.1E-09
	10	5.0E-10	1.0E-09	1.7E-09	2.6E-09	3.5E-09
	30	1.5E-09	3.0E-09	5.0E-09	7.6E-09	1.0E-08
164 Ho	3	2.2E-04	8.7E-05	1.8E-05	6.0E-06	2.6E-06
	10	2.3E-04	1.5E-04	4.9E-05	1.8E-05	8.1E-06
	30	2.4E-04	1.9E-04	1.1E-04	4.5E-05	2.2E-05
163 Er	3	1.5E-04	7.1E-05	1.6E-05	5.1E-06	1.9E-06
	10	1.6E-04	1.2E-04	4.2E-05	1.5E-05	6.9E-06
	30	1.7E-04	1.4E-04	8.9E-05	3.8E-05	1.9E-05
165 Er	3	1.5E-05	6.7E-06	1.4E-06	4.8E-07	2.0E-07
	10	1.6E-05	1.1E-05	3.8E-06	1.4E-06	7.2E-07
	30	1.8E-05	1.4E-05	8.4E-06	3.7E-06	1.9E-06

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
170 Tm	3	8.7E-11	4.6E-11	3.6E-11	5.1E-11	6.4E-11
	10	9.4E-11	7.6E-11	9.5E-11	1.5E-10	2.0E-10
	30	1.0E-10	9.2E-11	2.0E-10	3.9E-10	5.4E-10
169 Yb	3	2.4E-07	1.7E-07	5.2E-08	2.1E-08	1.1E-08
	10	2.6E-07	2.7E-07	1.3E-07	6.2E-08	3.5E-08
	30	2.8E-07	3.2E-07	2.8E-07	1.5E-07	9.2E-08
176 Lu	3	2.4E-15	2.3E-12	1.0E-11	3.3E-11	8.8E-11
	10	2.6E-15	3.5E-12	2.6E-11	9.6E-11	2.7E-10
	30	2.9E-15	4.3E-12	5.4E-11	2.4E-10	7.3E-10
175 Hf	3	1.0E-07	6.1E-08	1.6E-08	5.9E-09	3.0E-09
	10	1.1E-07	8.9E-08	4.1E-08	1.7E-08	9.5E-09
	30	1.2E-07	1.1E-07	8.2E-08	4.3E-08	2.6E-08
179 Ta	3	1.1E-08	5.6E-09	1.5E-09	6.3E-10	5.9E-10
	10	1.4E-08	8.6E-09	4.1E-09	2.2E-09	1.9E-09
	30	1.8E-08	1.3E-08	9.1E-09	6.0E-09	5.5E-09
180 Ta	3	1.8E-05	1.0E-05	2.1E-06	4.9E-07	2.4E-07
	10	1.9E-05	1.4E-05	5.3E-06	1.7E-06	7.5E-07
	30	2.1E-05	1.6E-05	1.0E-05	4.2E-06	2.0E-06
181 W	3	6.0E-08	3.8E-08	1.1E-08	3.9E-09	2.1E-09
	10	6.7E-08	5.3E-08	2.7E-08	1.2E-08	6.6E-09
	30	7.8E-08	6.9E-08	5.3E-08	3.0E-08	1.8E-08
186 Re	3	1.4E-07	9.5E-08	2.5E-08	7.9E-09	3.4E-09
	10	1.5E-07	1.3E-07	6.0E-08	2.3E-08	1.0E-08
	30	1.6E-07	1.4E-07	1.1E-07	5.4E-08	2.7E-08
185 Os	3	6.7E-08	4.7E-08	1.7E-08	7.7E-09	4.5E-09
	10	7.3E-08	6.2E-08	4.0E-08	2.2E-08	1.4E-08
	30	8.2E-08	7.3E-08	7.1E-08	5.2E-08	3.5E-08
187 Os	3	8.8E-13	2.8E-12	6.1E-12	9.3E-12	1.3E-11
	10	2.8E-12	7.8E-12	1.8E-11	2.9E-11	4.2E-11
	30	8.3E-12	2.1E-11	4.6E-11	8.0E-11	1.2E-10
192 Ir	3	4.3E-09	3.9E-09	1.6E-09	7.2E-10	3.9E-10
	10	4.7E-09	5.0E-09	3.8E-09	2.0E-09	1.2E-09
	30	5.2E-09	5.7E-09	6.4E-09	4.7E-09	3.1E-09
191 Pt	3	1.6E-06	1.4E-06	9.6E-07	6.3E-07	4.3E-07
	10	1.7E-06	1.7E-06	2.1E-06	1.7E-06	1.3E-06
	30	1.8E-06	1.8E-06	3.5E-06	4.0E-06	3.3E-06
193 Pt	3	2.6E-10	7.8E-11	7.3E-11	8.0E-11	8.9E-11
	10	5.3E-10	2.4E-10	2.1E-10	2.5E-10	2.9E-10
	30	9.0E-10	6.3E-10	5.9E-10	6.9E-10	8.1E-10
195 Au	3	3.5E-08	2.4E-08	1.0E-08	4.7E-09	2.8E-09
	10	4.5E-08	3.6E-08	2.4E-08	1.4E-08	9.0E-09
	30	6.0E-08	5.0E-08	4.6E-08	3.4E-08	2.4E-08
196 Au	3	1.0E-06	8.0E-07	2.5E-07	7.5E-08	3.1E-08
	10	1.1E-06	9.6E-07	5.3E-07	2.1E-07	9.2E-08
	30	1.2E-06	1.0E-06	8.4E-07	4.6E-07	2.3E-07
198 Au	3	2.7E-10	5.2E-09	5.0E-09	2.9E-09	1.8E-09
	10	2.9E-10	6.4E-09	1.1E-08	8.0E-09	5.4E-09
	30	3.2E-10	7.2E-09	1.8E-08	1.8E-08	1.4E-08

NUCLEUS	NE	T8=1	T8=2	T8=3	T8=4	T8=5
197 Hg	3	2.7E-06	2.1E-06	7.2E-07	2.4E-07	1.1E-07
	10	2.9E-06	2.5E-06	1.5E-06	6.7E-07	3.3E-07
	30	3.3E-06	2.9E-06	2.4E-06	1.5E-06	8.4E-07
204 Tl	3	1.2E-10	8.3E-10	3.7E-09	5.5E-09	5.5E-09
	10	1.4E-10	9.9E-10	8.7E-09	1.5E-08	1.6E-08
	30	1.7E-10	1.1E-09	1.3E-08	3.2E-08	4.1E-08
205 Pb	3	1.5E-09	5.6E-10	4.4E-10	4.9E-10	5.6E-10
	10	3.3E-09	1.8E-09	1.5E-09	1.6E-09	1.8E-09
	30	6.8E-09	4.7E-09	4.3E-09	4.6E-09	5.3E-09

Table III

NUCLEUS	NE	T8=1 B	T8=1 C	T8=2 B	T8=2 C	T8=3 B	T8=3 C	T8=4 B	T8=4 C	T8=5 B	T8=5 C
59 Ni	3	86	14	62	32	16	15	10	14	7	14
	10	83	17	62	36	29	30	20	31	15	31
	30	71	29	57	42	27	50	29	46	22	49
64 Cu	3	29	4	8	4	4	3	2	3	2	3
	10	48	9	20	10	11	10	7	9	5	9
	30	50	18	31	21	20	21	14	21	10	21
65 Zn	3	76	15	46	20	23	19	13	17	8	15
	10	83	14	58	28	37	33	25	33	18	32
	30	72	26	57	37	44	43	33	47	26	49
70 Ga	3	89	11	72	28	57	43	46	54	37	63
	10	87	13	70	30	55	45	44	56	32	68
	30	76	24	63	37	53	47	42	58	35	65
71 Ge	3	90	10	71	29	54	46	41	59	32	68
	10	87	13	68	32	52	48	40	60	31	69
	30	76	24	47	53	50	50	38	62	29	71
76 As	3	92	8	76	24	62	38	47	53	42	58
	10	90	10	74	26	60	40	43	57	41	59
	30	79	21	67	33	58	42	48	52	40	60
75 Se	3	93	7	77	23	63	37	51	49	42	58
	10	90	10	75	25	61	39	49	51	41	59
	30	80	20	69	31	58	42	48	52	39	61
79 Br	3	89	11	56	44	28	72	13	87	7	93
	10	84	16	54	46	26	74	13	87	6	94
	30	70	30	50	50	25	75	12	88	6	94
80 Br	3	42	3	12	3	5	3	3	2	2	2
	10	59	5	26	7	14	7	8	7	6	6
	30	58	13	42	14	26	16	18	16	13	16
82 Br	3	93	7	74	26	56	44	42	58	32	68
	10	90	10	72	28	55	45	41	59	31	69
	30	78	22	68	32	52	48	39	61	30	70
79 Kr	3	75	4	36	8	19	8	11	8	7	8
	10	82	7	55	14	36	18	25	19	18	19
	30	76	16	66	20	49	27	37	31	29	34
81 Kr	3	92	8	80	20	67	33	55	45	45	55
	10	88	12	78	22	65	35	53	47	44	56
	30	75	25	75	25	62	38	51	49	42	58
86 Rb	3	94	6	78	22	56	44	47	53	41	59
	10	91	9	76	24	51	49	46	54	40	60
	30	77	23	73	27	56	44	44	56	38	62
85 Sr	3	96	4	84	16	70	30	59	41	49	51
	10	93	7	81	19	68	32	57	43	48	52
	30	83	17	79	21	66	34	55	45	47	53
87 Sr	3	94	6	76	24	56	44	41	59	29	71
	10	91	9	73	27	54	46	39	61	28	72
	30	78	22	70	30	52	48	38	62	27	73

NUCLEUS	NE	T8=1		T8=2		T8=3		T8=4		T8=5	
		B	C	B	C	B	C	B	C	B	C
94 Nb	3	37	63	13	87	10	90	9	91	7	93
	10	34	66	13	87	10	90	8	92	7	93
	30	30	70	13	87	9	91	8	92	6	94
93 Mo	3	96	4	78	22	65	35	49	51	36	64
	10	93	7	73	27	63	37	47	53	35	65
	30	85	15	77	23	60	40	45	55	33	67
97 Tc	3	97	3	89	11	78	22	67	33	57	43
	10	95	5	86	14	76	24	66	34	56	44
	30	89	11	85	15	74	26	63	37	54	46
98 Tc	3	97	2	86	10	73	19	60	26	49	32
	10	95	5	86	13	76	21	65	30	55	38
	30	90	10	85	14	74	24	65	34	56	42
97 Ru	3	98	2	91	9	81	19	71	29	62	38
	10	96	4	89	11	79	21	69	31	60	40
	30	90	10	86	14	76	24	67	33	59	41
104 Rh	3	98	2	92	8	82	18	72	27	64	36
	10	96	4	90	10	81	19	71	29	63	37
	30	91	9	87	12	78	22	69	31	61	39
103 Pd	3	98	2	92	8	82	18	71	29	62	38
	10	96	4	90	10	80	20	70	30	61	39
	30	91	9	87	13	78	22	68	32	59	41
107 Ag	3	95	5	75	25	49	51	30	70	16	84
	10	89	11	72	28	47	53	29	71	18	82
	30	78	22	67	33	44	56	28	72	18	82
108 Ag	3	85	1	47	3	23	4	13	4	7	4
	10	86	3	68	6	44	9	29	10	20	10
	30	83	8	77	9	60	14	46	17	36	19
110 Ag	3	98	2	93	7	84	16	75	25	62	38
	10	96	4	92	8	83	17	74	26	65	35
	30	91	9	89	11	80	20	71	29	63	37
107 Cd	3	98	1	92	6	82	14	71	21	60	28
	10	96	3	92	7	83	15	74	24	65	31
	30	92	8	90	10	81	18	73	26	65	34
109 Cd	3	97	3	85	15	66	34	50	50	38	62
	10	93	7	83	17	64	36	48	52	38	62
	30	85	15	78	22	61	39	46	54	36	64
113 In	3	96	4	81	19	57	43	37	63	24	76
	10	91	9	78	22	55	45	36	64	24	76
	30	81	19	72	28	52	48	35	65	23	77
114 In	3	98	1	90	5	75	11	61	17	49	21
	10	96	3	92	6	81	14	71	21	61	27
	30	91	8	90	9	81	17	72	24	64	31
116 In	3	99	1	94	6	85	15	75	25	65	35
	10	96	4	92	8	83	17	74	26	64	36
	30	91	9	89	11	81	19	71	29	62	38
113 Sn	3	99	1	95	5	88	12	79	21	71	29
	10	97	3	94	6	86	14	78	22	70	30
	30	92	8	91	9	84	16	76	24	68	32

NUCLEUS	NE	T8=1		T8=2		T8=3		T8=4		T8=5	
		B	C	B	C	B	C	B	C	B	C
122 Sb	3	98	1	87	4	51	7	26	8	20	7
	10	96	3	91	6	70	10	52	13	40	15
	30	92	8	90	9	77	14	65	19	54	23
121 Te	3	99	1	95	5	88	12	79	20	70	28
	10	97	3	94	6	87	13	78	22	70	29
	30	92	8	91	9	84	16	76	24	68	31
123 Te	3	92	8	69	31	40	60	22	78	13	87
	10	84	16	66	34	39	61	22	78	13	87
	30	71	29	60	40	37	63	21	79	13	87
125 I	3	98	2	93	7	80	20	65	35	52	48
	10	95	5	91	9	78	22	64	36	51	49
	30	89	11	86	14	75	25	61	39	39	61
126 I	3	96	1	63	2	24	3	11	2	6	2
	10	95	3	79	4	47	6	27	6	17	6
	30	91	7	83	7	63	10	46	11	25	14
128 I	3	99	1	96	4	90	10	81	17	73	25
	10	97	3	95	5	89	11	81	18	73	26
	30	93	7	92	8	87	13	79	21	63	36
125 Xe	3	98	1	93	3	78	8	57	11	38	12
	10	97	3	94	4	85	9	72	15	51	21
	30	93	7	92	7	86	12	76	18	65	24
127 Xe	3	99	1	96	4	89	11	80	20	72	28
	10	97	3	95	5	88	12	79	21	65	35
	30	92	8	91	9	85	15	77	23	68	32
131 Cs	3	99	1	96	4	89	11	80	20	71	29
	10	97	3	95	5	88	12	79	21	69	31
	30	92	8	92	8	85	15	77	23	67	33
134 Cs	3	99	1	96	3	89	9	79	15	69	21
	10	97	3	95	5	89	10	82	16	73	23
	30	92	8	92	8	87	12	80	19	73	26
131 Ba	3	99	1	97	3	91	8	81	14	70	20
	10	97	3	96	4	90	9	83	16	74	22
	30	93	7	93	7	88	12	75	25	74	24
133 Ba	3	99	1	97	3	91	9	83	17	74	26
	10	97	3	96	4	89	11	81	19	73	27
	30	93	7	93	7	87	13	72	28	71	29
137 La	3	99	1	97	3	90	10	85	15	77	23
	10	97	3	96	4	91	9	84	16	76	24
	30	93	7	93	7	88	12	80	20	74	26
138 La	3	99	1	97	3	73	9	33	6	16	4
	10	97	3	96	4	85	9	56	11	35	10
	30	92	8	92	8	85	12	67	16	53	17
137 Ce	3	99	1	98	2	93	7	87	13	80	19
	10	98	2	97	3	92	8	86	14	79	21
	30	94	6	94	6	90	10	84	16	78	22
139 Ce	3	98	2	92	8	77	23	59	41	43	57
	10	94	6	90	10	75	25	58	42	42	58
	30	86	14	84	16	71	29	54	46	40	60

NUCLEUS	NE	T8=1 B	T8=1 C	T8=2 B	T8=2 C	T8=3 B	T8=3 C	T8=4 B	T8=4 C	T8=5 B	T8=5 C
142 Pr	3	99	1	97	3	90	10	82	18	74	26
	10	97	3	95	5	89	11	76	24	73	27
	30	92	8	91	9	86	14	79	21	71	29
145 Pm	3	98	2	96	4	87	13	74	26	61	39
	10	95	5	94	6	85	15	72	28	60	40
	30	89	11	89	11	77	23	70	30	58	42
148 Pm	3	99	1	98	2	94	6	88	12	80	20
	10	98	2	97	3	93	7	86	14	79	21
	30	94	6	94	6	88	12	85	15	77	23
145 Sm	3	99	1	98	2	94	6	89	11	81	19
	10	98	2	97	3	93	7	87	13	80	20
	30	94	6	94	6	90	10	86	14	79	21
152 Eu	3	98	1	95	1	85	4	71	7	57	10
	10	97	2	96	2	91	5	82	9	73	14
	30	94	5	94	5	90	7	86	11	78	16
154 Eu	3	99	1	99	1	95	5	90	10	84	16
	10	98	2	98	2	94	6	89	11	83	17
	30	94	6	95	5	92	8	87	13	81	19
153 Gd	3	98	2	95	5	88	12	78	22	68	32
	10	95	5	94	6	83	17	76	24	66	34
	30	88	12	87	13	83	17	74	26	64	36
157 Tb	3	90	10	78	22	58	42	42	58	36	64
	10	81	19	73	27	53	47	40	60	35	65
	30	68	32	62	38	52	48	39	61	33	67
158 Tb	3	98	2	98	2	96	4	91	8	86	13
	10	94	6	98	2	95	5	91	9	85	14
	30	87	13	94	6	94	6	90	10	84	16
160 Tb	3	99	1	97	3	91	9	81	19	69	31
	10	96	4	96	4	89	11	79	21	67	33
	30	91	9	91	9	87	13	77	23	65	35
157 Dy	3	99	1	99	1	97	3	92	8	87	13
	10	98	2	98	2	96	4	91	9	86	14
	30	95	5	96	4	94	6	90	10	85	15
159 Dy	3	99	1	98	2	94	6	87	13	76	24
	10	98	2	97	3	93	7	85	15	75	25
	30	94	6	94	6	91	9	83	17	73	27
163 Ho	3	2	98	1	99	1	99	1	99	1	99
	10	1	99	1	99	1	99	1	99	1	99
	30	2	98	0	100	1	99	1	99	1	99
164 Ho	3	99	1	99	1	97	3	93	7	88	12
	10	98	2	98	2	96	4	92	8	87	13
	30	95	5	96	4	95	5	91	9	85	15
163 Er	3	99	1	99	1	97	3	93	6	87	13
	10	98	2	98	2	96	4	93	7	88	12
	30	95	5	96	4	95	5	91	9	86	13
165 Er	3	99	1	99	1	96	4	91	9	81	19
	10	98	2	98	2	95	5	90	10	83	17
	30	94	6	95	5	93	7	88	12	81	19

NUCLEUS	NE	T8=1		T8=2		T8=3		T8=4		T8=5	
		B	C	B	C	B	C	B	C	B	C
170 Tm	3	99	1	99	1	96	4	92	8	86	14
	10	97	3	98	2	95	5	91	9	85	15
	30	94	6	94	6	94	6	89	11	83	17
169 Yb	3	99	1	99	1	97	3	94	6	88	12
	10	98	2	98	2	96	4	93	7	88	12
	30	95	5	95	5	95	5	91	9	86	14
176 Lu	3	99	1	99	1	96	4	92	8	86	14
	10	97	3	97	3	95	5	91	9	85	15
	30	93	7	93	7	93	7	89	11	84	16
175 Hf	3	99	1	99	1	96	4	90	10	83	17
	10	97	3	97	3	95	5	89	11	82	18
	30	93	7	94	6	93	7	87	13	80	20
179 Ta	3	98	2	96	4	87	13	61	39	41	59
	10	94	6	92	8	84	16	63	37	39	61
	30	86	14	85	15	79	21	60	40	37	63
180 Ta	3	99	1	99	1	98	2	94	6	91	9
	10	98	2	98	2	97	3	94	6	90	10
	30	95	5	96	4	96	4	93	7	89	11
181 W	3	99	1	98	2	95	5	87	13	76	24
	10	97	3	96	4	93	7	86	14	75	25
	30	92	8	92	8	90	10	83	17	72	28
186 Re	3	99	1	99	1	98	2	95	5	91	9
	10	98	2	98	2	97	3	94	6	90	10
	30	95	5	96	4	96	4	93	7	88	12
185 Os	3	99	1	99	1	98	2	95	5	91	9
	10	97	3	98	2	97	3	94	6	90	10
	30	93	7	94	6	94	6	92	8	88	12
187 Os	3	7	93	31	69	43	57	44	56	41	59
	10	8	92	21	79	37	63	41	59	39	61
	30	10	90	15	85	31	69	37	63	37	63
192 Ir	3	99	1	99	1	98	2	96	4	92	8
	10	98	2	98	2	97	3	95	5	91	9
	30	94	6	95	5	95	5	93	7	89	11
191 Pt	3	99	1	99	1	99	1	97	3	93	7
	10	98	2	99	1	98	2	96	4	93	7
	30	95	5	96	4	96	4	95	5	91	9
193 Pt	3	86	14	55	45	48	52	45	55	41	59
	10	78	22	54	46	42	58	42	58	39	61
	30	64	36	48	52	39	61	39	61	36	64
195 Au	3	97	3	97	3	92	8	83	17	71	29
	10	93	7	93	7	89	11	80	20	69	31
	30	86	14	85	15	84	16	77	23	66	34
196 Au	3	100	0	100	0	99	1	97	3	94	6
	10	98	2	99	1	98	2	96	4	93	7
	30	96	4	97	3	97	3	95	5	92	8
198 Au	3	99	1	99	1	98	2	96	4	91	9
	10	98	2	98	2	98	2	95	5	90	10
	30	95	5	96	4	95	5	93	7	88	12

NUCLEUS	NE	T8=1		T8=2		T8=3		T8=4		T8=5	
		B	C	B	C	B	C	B	C	B	C
197 Hg	3	99	1	99	1	98	2	95	5	91	9
	10	98	2	98	2	97	3	94	6	90	10
	30	95	5	95	5	95	5	93	7	88	12
204 Tl	3	98	2	99	1	99	1	97	3	93	7
	10	96	4	98	2	98	2	96	4	92	8
	30	90	10	95	5	96	4	94	6	91	9
205 Pb	3	82	18	46	54	16	84	12	88	10	90
	10	75	25	44	56	19	81	11	89	9	91
	30	65	35	39	61	21	79	10	90	8	92

Figure Captions

Fig. 1a Ratio between the rates of the bound-state β^--decay $\lambda_{b\beta^-}$ and of the continuum-state β^--decay $\lambda_{c\beta^-}$ for allowed and non-unique first forbidden transitions. The abscissa Q_n represents the neutral atomic mass difference between the initial and final atoms. The atoms are assumed to be completely ionized, and all the possible contributions up to the 6s electron shell are taken into account. The electron radial wave functions are evaluated at the nuclear radius of $1.2\times A^{1/3}$ fm.

Fig. 1b Same as Fig. 1a but for unique first forbidden transitions

Fig. 2 Decay schemes for the examples discussed in detail. The adopted log ft values for some important transitions under s-process conditions (see text for the explanation) are indicated by parentheses, while the values without parentheses are those of experimentally known transitions.

Fig. 3a Comparison between the present results λ_p and those of Cosner and Truran[9] λ_{CT} for the total effective β^--decay rates at $T=3\times10^8$ (K) and $n_e=10^{27}$ (cm^{-3}). The ratio λ_{CT}/λ_p for ^{182}Ta exceeds 10^3.

Fig. 3b Same as Fig. 3a but for the total effective electron-capture and β^+-decay rates. The ratio λ_{CT}/λ_p for ^{160}Tb exceeds 10^3.

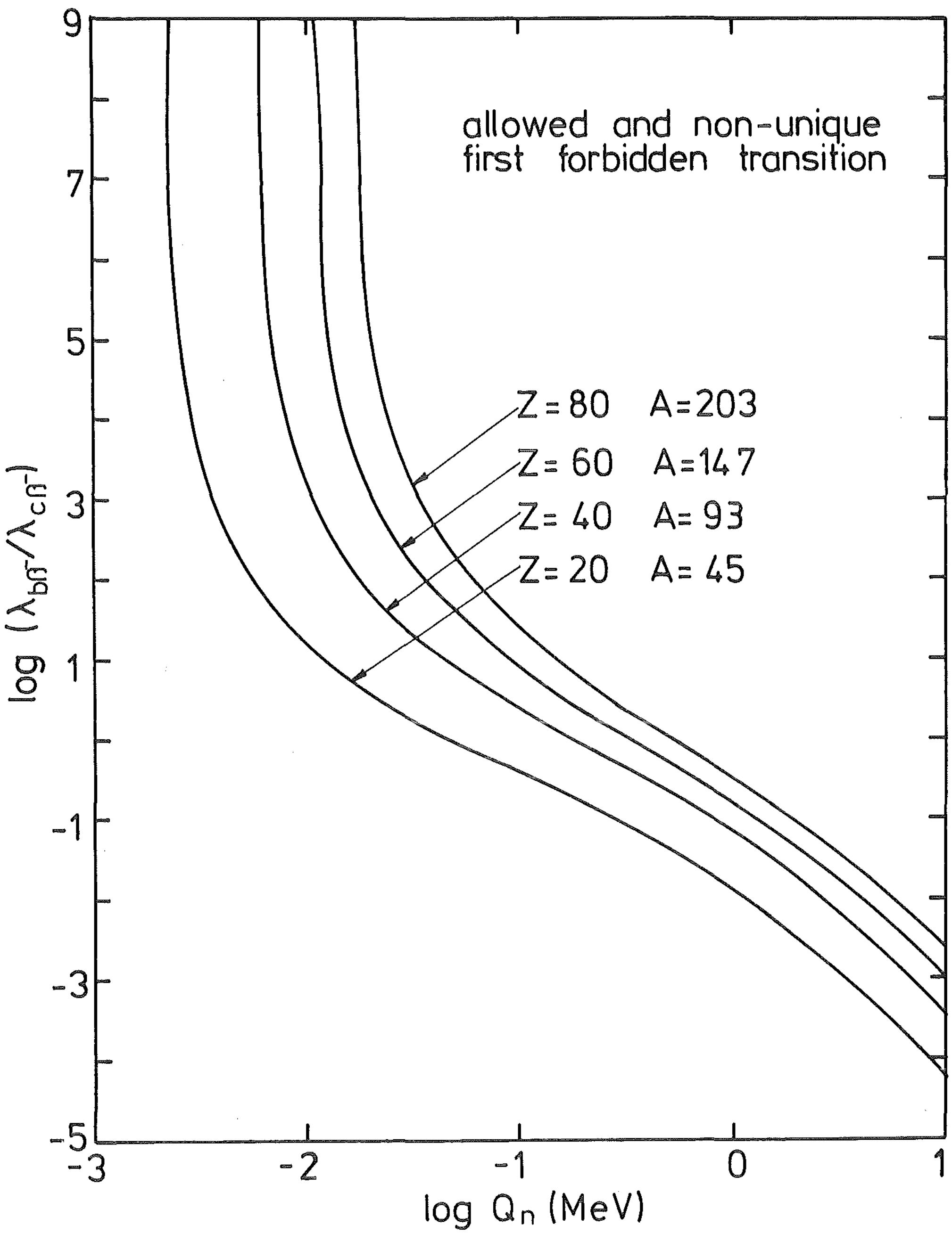

allowed and non-unique
first forbidden transition
Z = 80 A = 203
Z = 60 A = 147
Z = 40 A = 93
Z = 20 A = 45
log $(\lambda_{b\beta^-}/\lambda_{c\beta^-})$
log Q_n (MeV)
9
7
5
3
1
-1
-3
-5
-3
-2
-1
0
1

Fig. 1a

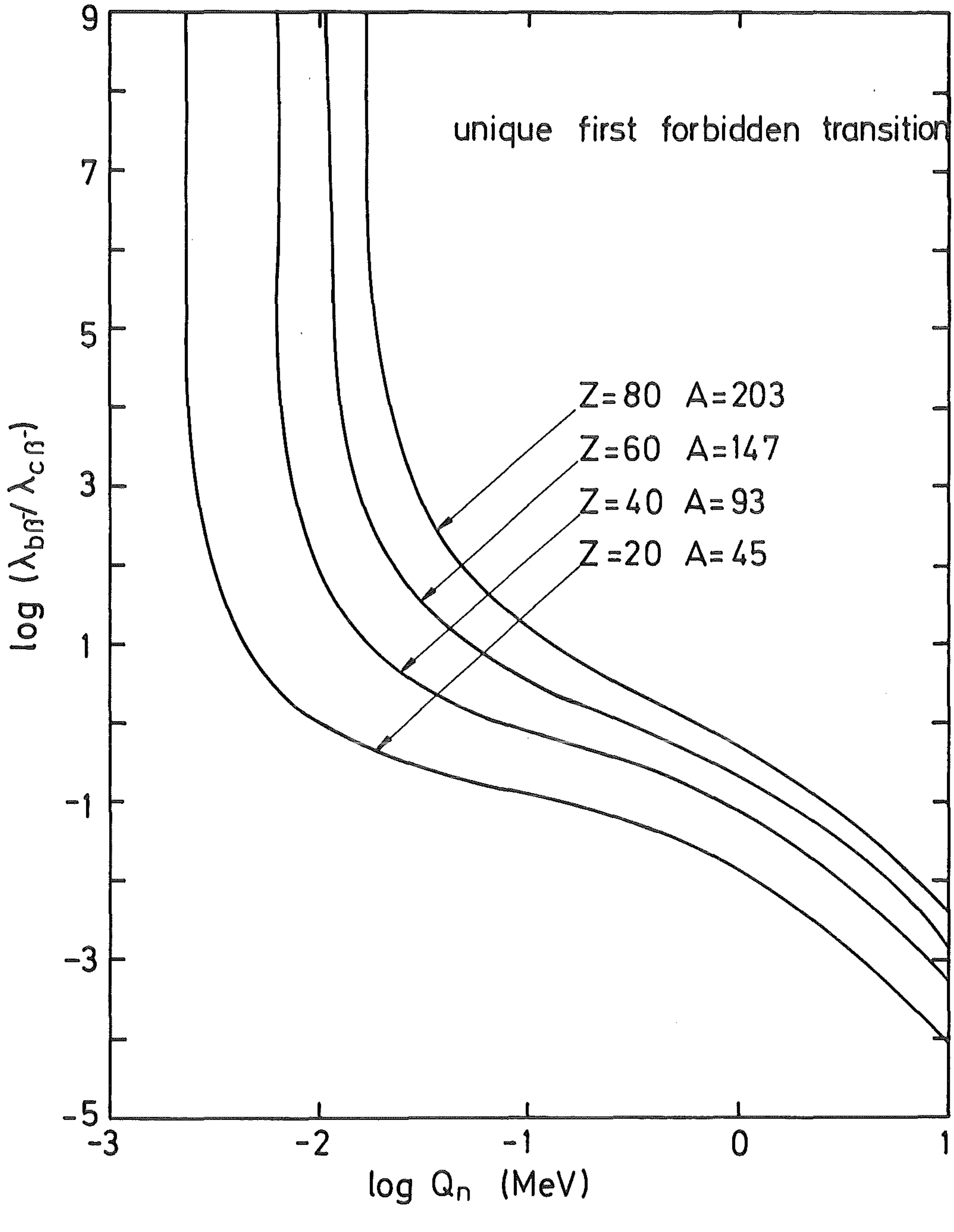

unique first forbidden transition
Z=80 A=203
Z=60 A=147
Z=40 A=93
Z=20 A=45
log ($\lambda_{b\beta^-}/\lambda_{c\beta^-}$)
log Q_n (MeV)
9
7
5
3
1
-1
-3
-5
-3
-2
-1
0
1

Fig. 1b

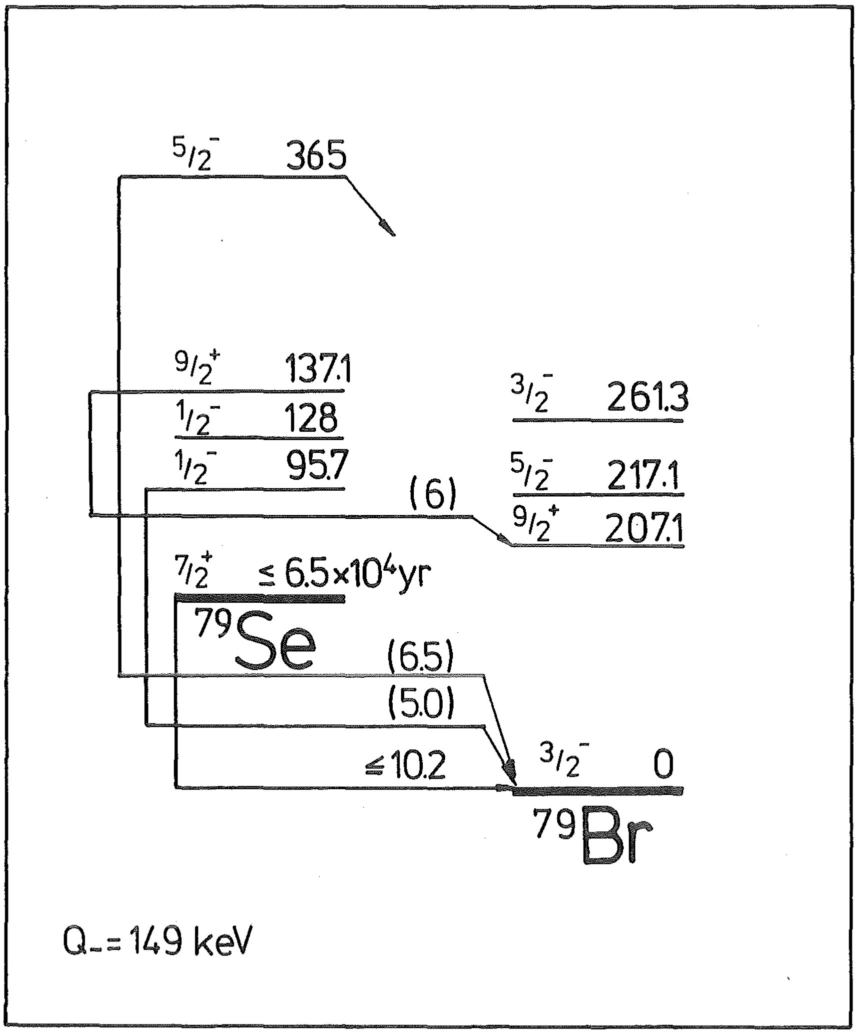
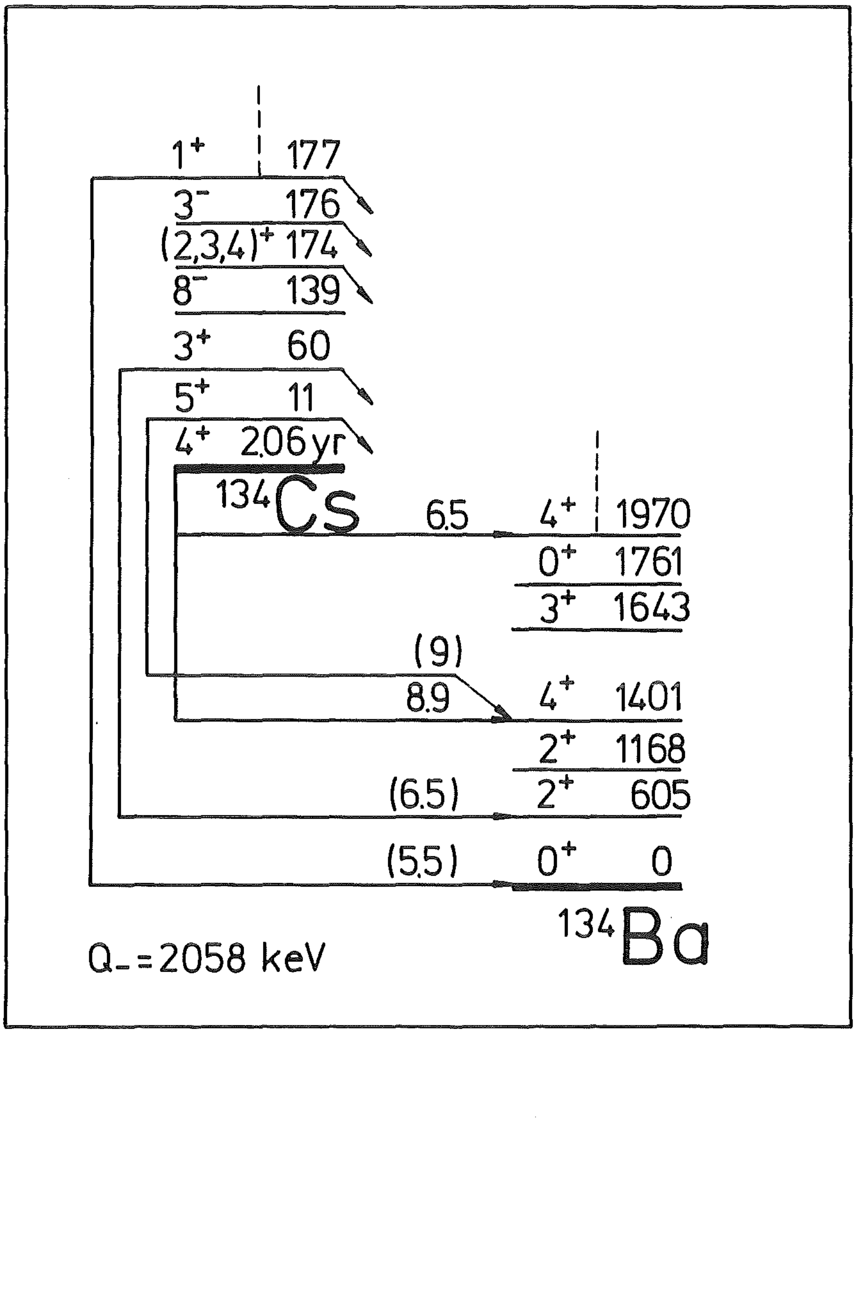

5/2⁻ 365
9/2⁺ 137.1
1/2⁻ 128
1/2⁻ 95.7
7/2⁺ ≤ 6.5×10⁴yr
79Se
3/2⁻ 261.3
5/2⁻ 217.1
9/2⁺ 207.1
(6)
(6.5)
(5.0)
≤10.2
3/2⁻ 0
79Br
Q₋= 149 keV

Fig. 2a



1⁺ 177
3⁻ 176
(2,3,4)⁺ 174
8⁻ 139
3⁺ 60
5⁺ 11
4⁺ 2.06 yr
134Cs
6.5
4⁺ 1970
0⁺ 1761
3⁺ 1643
(9)
8.9
4⁺ 1401
2⁺ 1168
(6.5)
2⁺ 605
(5.5)
0⁺ 0
134Ba
Q₋ = 2058 keV

Fig. 2b

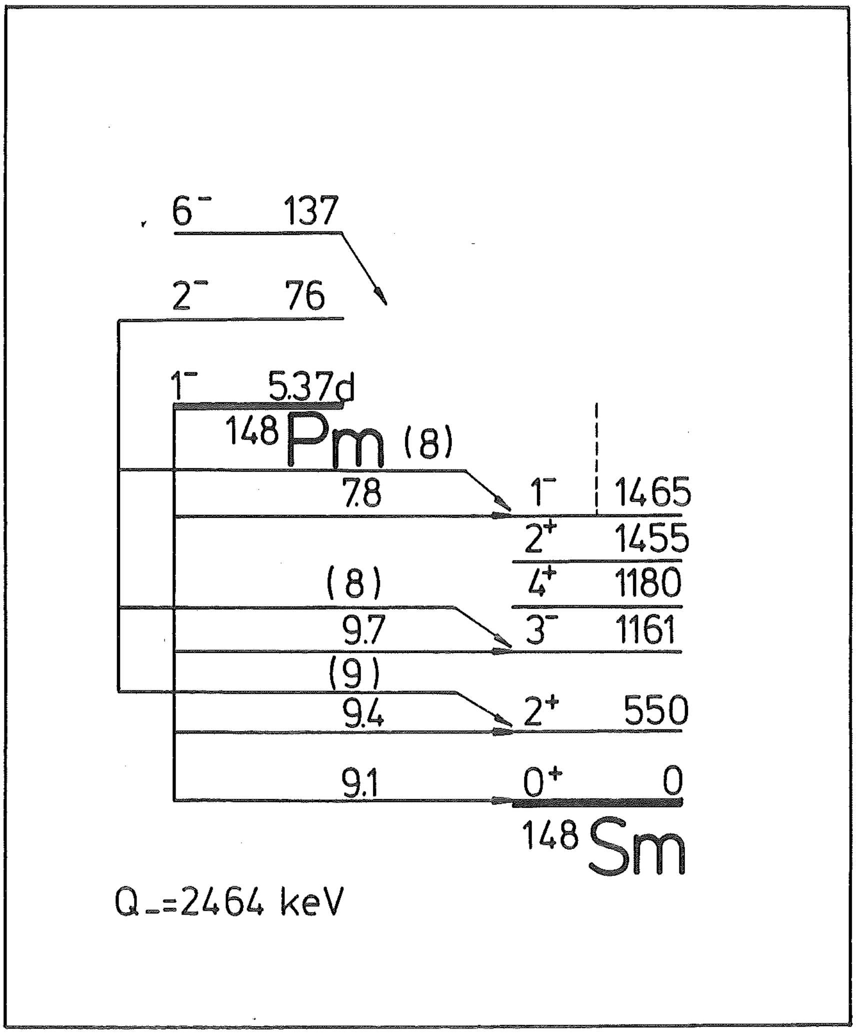
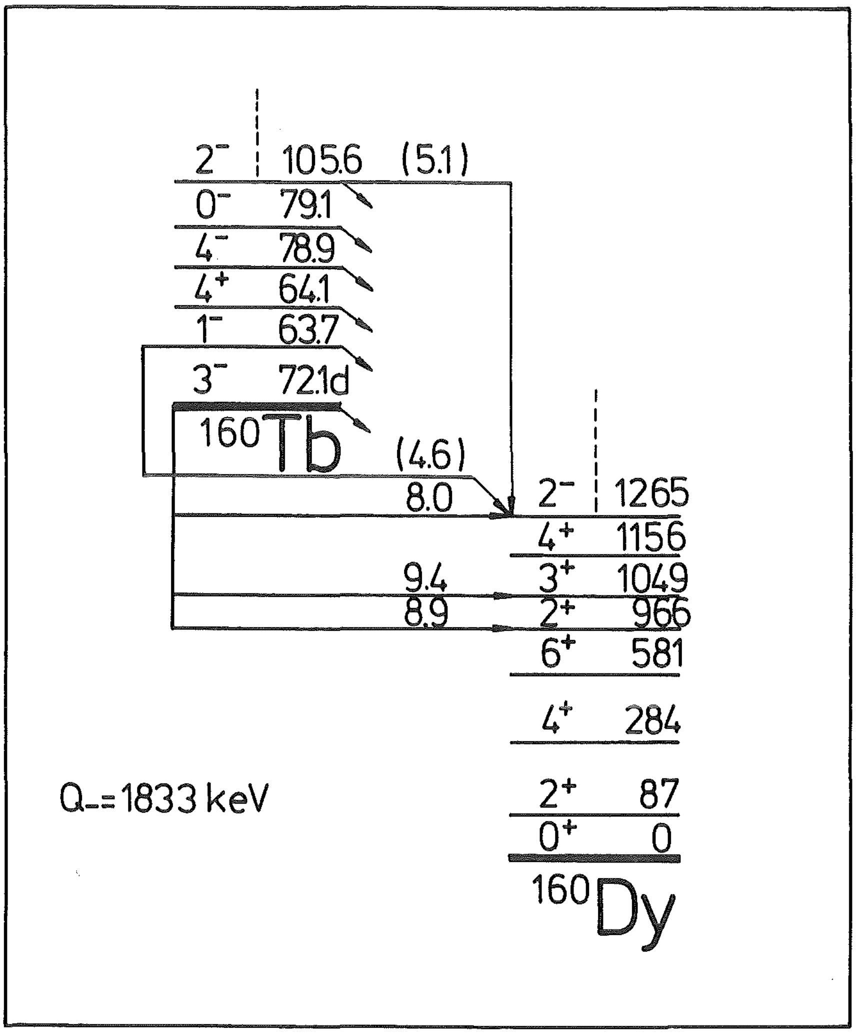

6⁻ 137
2⁻ 76
1⁻ 5.37d
148 Pm
(8)
7.8
1⁻ 1465
2⁺ 1455
(8)
4⁺ 1180
9.7
3⁻ 1161
(9)
9.4
2⁺ 550
9.1
0⁺ 0
148 Sm
Q₋=2464 keV

Fig. 2c



2⁻
105.6
(5.1)
0⁻
79.1
4⁻
78.9
4⁺
64.1
1⁻
63.7
3⁻
72.1d
160Tb
(4.6)
8.0
9.4
8.9
2⁻
1265
4⁺
1156
3⁺
1049
2⁺
966
6⁺
581
4⁺
284
2⁺
87
0⁺
0
160Dy
Q₋=1833 keV

Fig. 2d

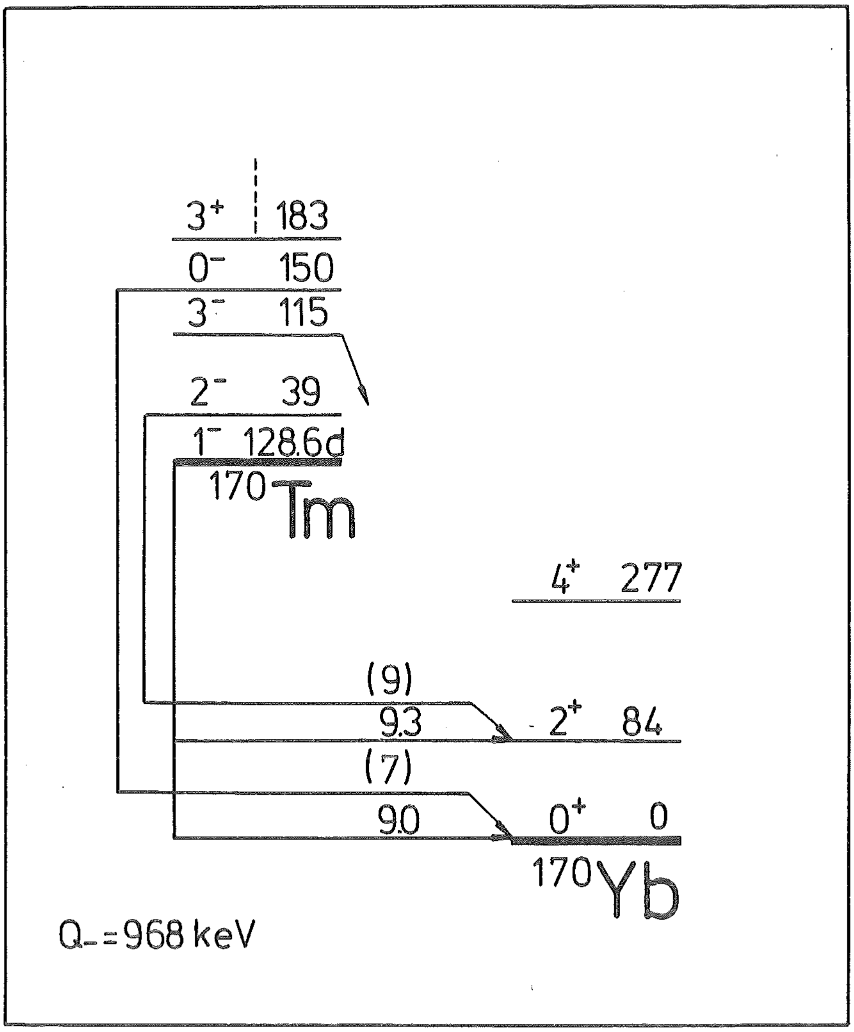

3+ 183
0− 150
3− 115
2− 39
1− 128.6d
170Tm
4+ 277
(9)
9.3
2+ 84
(7)
9.0
0+ 0
170Yb
Q− = 968 keV

Fig. 2e

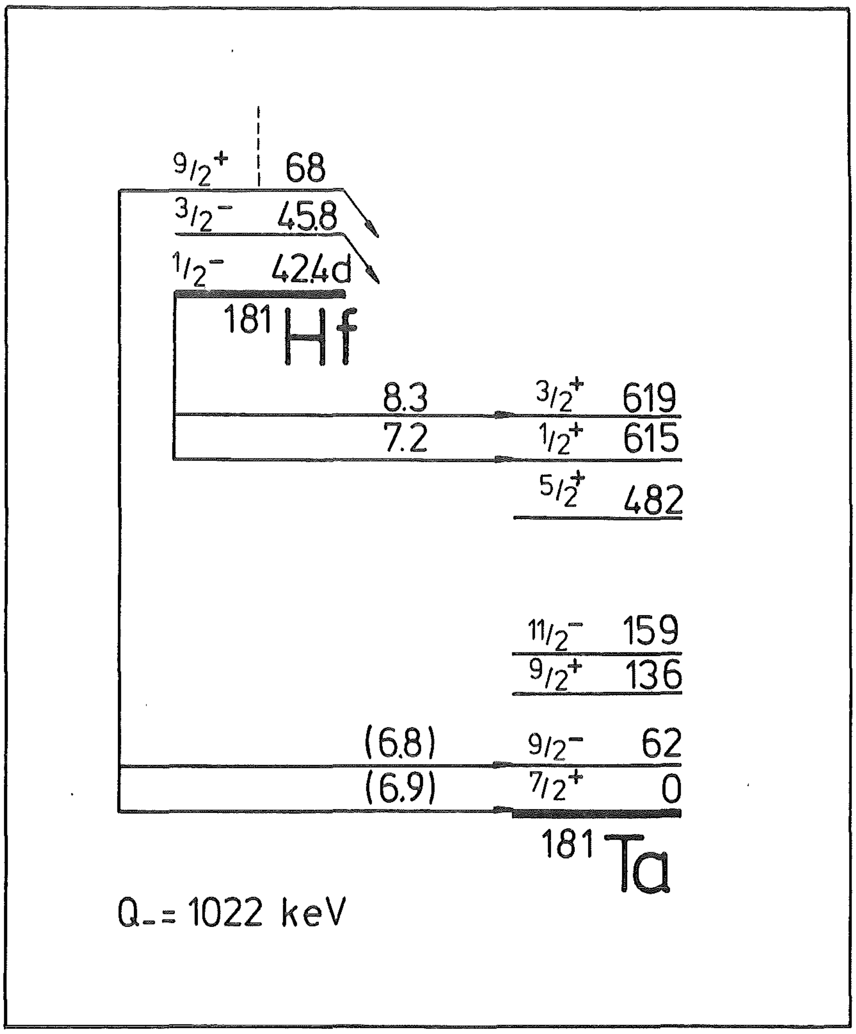

9/2+ 68
3/2− 45.8
1/2− 42.4d
181Hf
8.3
7.2
3/2+ 619
1/2+ 615
5/2+ 482
11/2− 159
9/2+ 136
(6.8)
(6.9)
9/2− 62
7/2+ 0
181Ta
Q− = 1022 keV

Fig. 2f

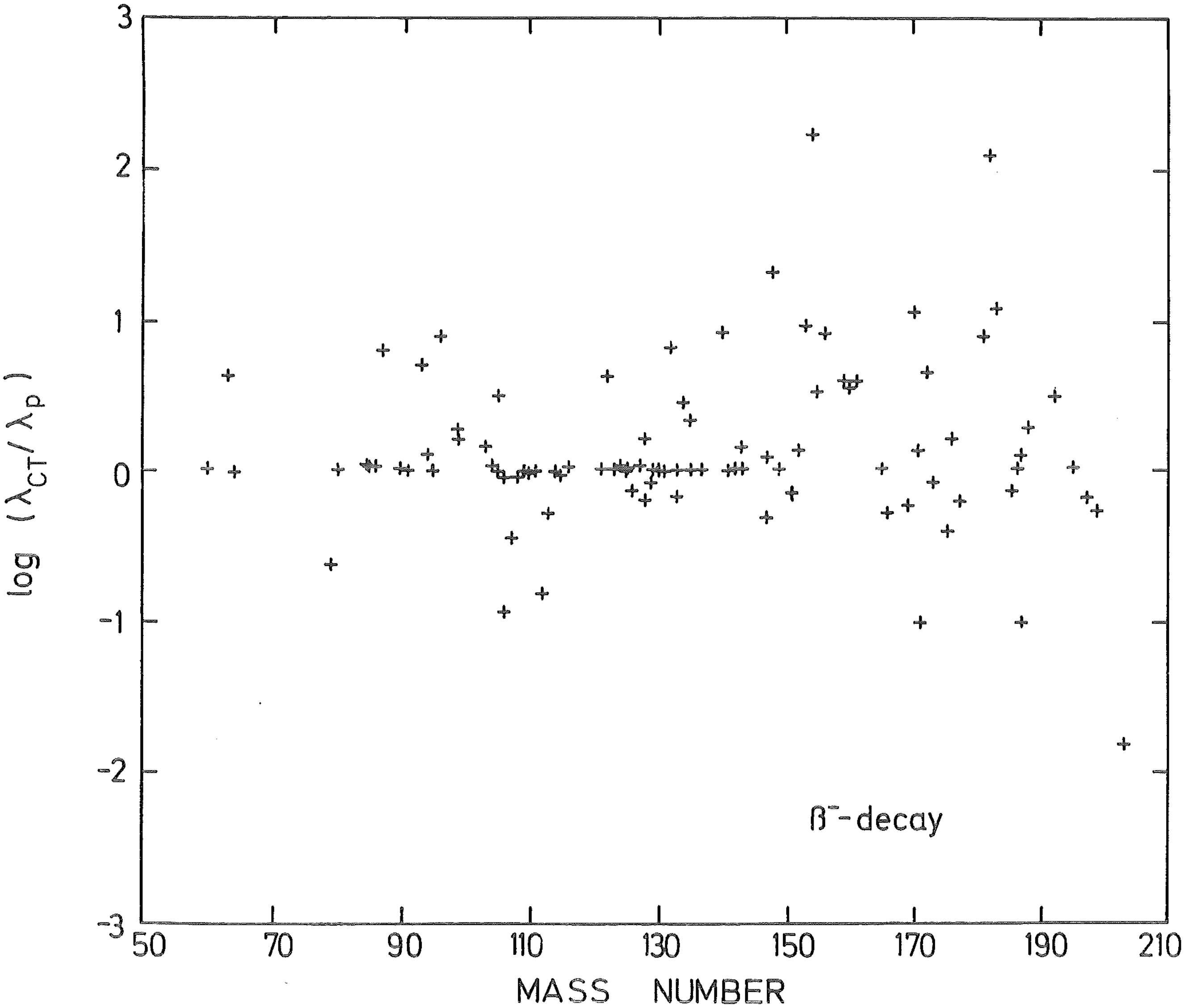

3
2
1
0
-1
-2
-3
log (λ_{CT}/λ_p)
β⁻-decay
50
70
90
110
130
150
170
190
210
MASS NUMBER

Fig. 3a

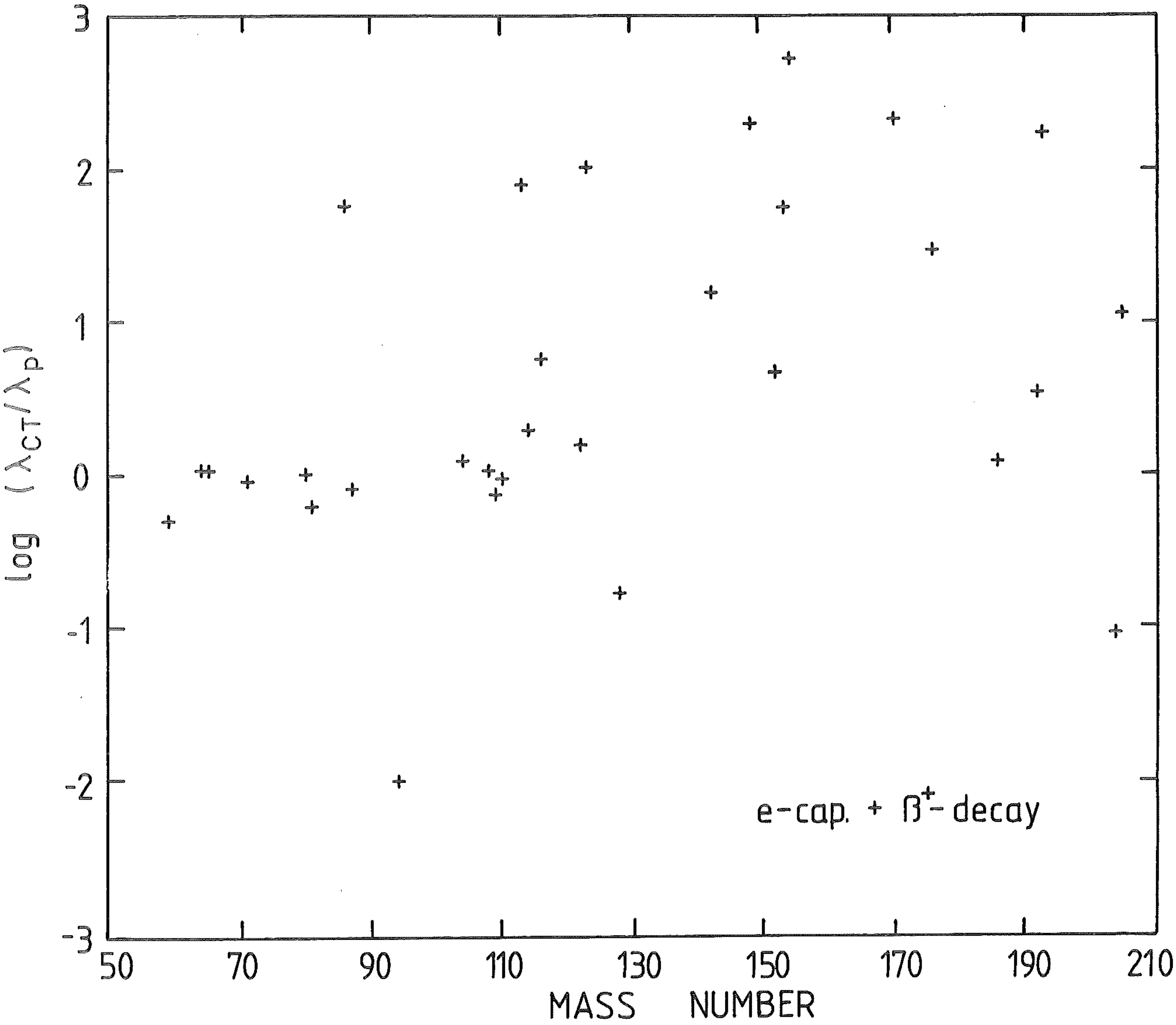

3
2
1
0
-1
-2
-3
log (λ_{CT}/λ_P)
50
70
90
110
130
150
170
190
210
MASS NUMBER
e-cap. + β^+- decay

Fig. 3b