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STATUS OF THE ATOMIC MASS EVALUATION

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Abstract

This paper gives the present status of the Atomic Mass Evaluation and comments on adopted new procedures and policies. A discussion is given of the most relevant recent data for mass determination.

1. Calendar for the Atomic Mass Evaluations

Given the strong demand for an up-to-date table of masses, we decided that, after the completion of the 1993 Atomic Mass Evaluation (AME-93) [I]–[IV], updates should be made available regularly (every two years). The updates should be accompanied by electronic versions of the full mass table and tables of reaction and separation energies, distributed by the nuclear data centers as for the 1993 ones. The paper version of the updates should be short and contain only a table of mass excesses in keV, a list of new or revised input data, a list of references to these data, and comments on the new data and their evaluation.

It is therefore planned to calculate an update of the AME-93 in summer 1995, after having included data presented at the present ENAM'95 conference, and to have it published before the end of the year. A second update is foreseen 2 years later, followed by a full publication of the AME in 1999.

The cut-off date of the data from literature to be used in AME-95 is April 30, 1995. Preprints and private communications that we will receive before June 30, 1995 will also be included. Final calculation will most probably be performed in September 1995.

2. New features

In AME-93, the published mass excesses and nuclear-reaction and separation energies were those *"derived from all experimental data"* where available. Special tables gave cases where, based on an analysis of systematic trends of masses, or of mass differences like decay and neutron and proton binding energies, we recommended to replace some particular (see section 7) experimental data by values considered more dependable. In the update, the more widely used *"recommended values"* for masses will be given. A table will list the few new or removed cases in this category.

The names and the chemical symbols of the elements 104 to 109 as recommended recently by the Commission on Nomenclature of Inorganic Chemistry of the International Union of Pure and Applied Chemistry (IUPAC) will be used: 104 dubnium (Db), 105 joliotium (Jl), 106 rutherfordium (Rf), 107 bohrium (Bh), 108 hahnium (Hn), and 109 meitnerium (Mt). This choice is made for convenience and does not express a preference. For the elements 110 and 111 we will use the provisional symbols Xa and Xb.

Among the new features in the coming evaluation, one will find an improved treatment of isomers. One section of the present paper (section 6) is devoted to this issue and gives full description of the changes in policies concerning isomers.

In making estimates for unknown masses we take into account all available experimental information. In particular, knowledge on stability or instability against particle emission or limits on proton or alpha emission yield upper or lower limits on the separation energies.

3. New elements and a new (semi-) magic number

Very recently, the Darmstadt group [95Ho.1], [95Ho.A] and [95Ho.2] announced the discovery of isotopes ^{269}Xa, ^{271}Xb and ^{272}Xb of the elements 110 and 111. Earlier, a Berkeley group [95Ghio] had announced the possible observation of ^{267}Xa. Although the reported α-particle energies probably do not belong to branches to the ground-states of their daughters, they nevertheless give information of use for getting good estimates of the masses for very heavy nuclides.

Another important discovery in this region is due to a collaboration of Livermore and Dubna who found the existence of a sub-shell closure at N=162. In a first paper they reported the observation of two new isotopes of element Z=106 and interpreted the results as evidence for extra stability at Z=108 and N=162 [94Laza]. And at this ENAM'95 conference, Oganessian et al. [95Ogan] reported the discovery of ^{273}Xa, the first nuclide with N=163, which exhibits a strong increase of the α-energy, strongly indicating the subshell closure at N=162. Such an effect could be responsible for the amazing fact that the increasing probability for spontaneous fission, so evident for elements until Z=104, is far less prominent than expected beyond the latter element. One of us [95Waps] plans to publish an analysis of some of these points and the ones discussed below (section 5.4). It is also interesting to note that, in a recent paper, Brenner et al. found, in an analysis of the first 2^+ states in even-even nuclides, that a spherical subshell might close at N=164 [95Bren]. It would be interesting to repeat this analysis with the assumption of a sub-shell closure at N=162 as observed by [95Ogan].

4. New data from mass spectrometry

4.1. Stable nuclides

Data with high precision (of the order of 1 part in 10^{10}) are reported by the MIT group [94DiFi] using a Penning-trap spectrometer. A careful evaluation of the systematic errors and analysis of the obtained data allowed this group to achieve very satisfactory internal consistency checks.

Their impressive report [94DiFi] is, in this sense, recommendably complete. Yet, they should not remain unchallenged: checks by another group, at the same level of precision, are highly desirable to strengthen the validity of their mass measurements, and transform these very precise measurements into very accurate ones. Some of their results were already used in the 1993 tables and have been revised only slightly (except for the ^{12}C+^{2}H–^{14}N combination). New is the result for ^{28}Si where 2 orders of magnitude in precision have been gained compared to AME-93. From this result follow improved values for the other stable Si isotopes. This may become important in future for the definition of the mass unit, the kg. If it is defined in terms of the atomic mass unit, by accepting a defined value for the Avogadro constant, realization of a mass standard may be best done by constructing an ultrapure Si crystal. New also is the result for ^{15}N, of importance for the calibration of γ-ray energies (see section 5.1).

Other groups working with Penning-trap spectrometers in Ohio and Stockholm have obtained results for D, ^{20}Ne, ^{22}Ne and ^{28}Si (and a preliminary value for the hydrogen mass) which confirm, at their respective level of accuracies, the corresponding more precisely known masses.

Classical mass-spectrometry on stable and nearly β-stable nuclides along the "backbone" is also producing results, like the new values for Xe, obtained at Winnipeg. Their planned measurements on Hg isotopes to solve the mercury problem (section 7 in [IV]) are eagerly awaited.

4.2. Nuclides far from stability

The regions somewhat removed from the line of stability, especially the most exotic nuclides, are of interest in helping to determine the yet poorly known behavior of the binding energies for large differences between numbers of neutrons and of protons. This is reflected in the excessively large deviations amongst the predictions of the models (see e.g. ref. [93Borc]) especially along the astrophysical r-process paths. And yet the longest isotopic chains known with fair precision (40 keV) do not exceed 33 nuclides (for Pb) or 28 in the case of Cs.

We must, in the first place, mention the new Penning trap measurements [95Hart], [95Boll] on heavy Rb, Sr, Cs and Ba isotopes, obtained after the move to the new ISOLDE facility. They led to drastically improved accuracies far from stability. A very recent improvement in the set-up [95Raim] now allows mass-measurements of some rare-earth nuclides (^{139,140,142,143}Sm, ^{139}Eu), the results of which are, unfortunately, not yet available and will not be included in the coming AME-95 update. For the lighter Rb isotopes, the differences with earlier data on isobaric Sr mass values, agree quite well with the reported values for the Rb(β^-)Sr decay energies. This makes it even more amazing that the new Sr values do not agree so well with the reported β-decay energies of these isotopes and their daughters. The dependability of the Penning-trap measurements after dismounting and reassembly of the apparatus is assessed by the perfect agreement obtained for the heavy Cs and Ba isotopes before and after the move. In our 1993 mass adjustment, the ^{91}Sr(β^-) decay energy was already one of the three somewhat severe difficulties mentioned in setion 3.2 of [IV]. Values of 2669(10) [53Am08], 2684(4) [73Ha11] and 2704.5(3.0) keV [80De02] were reported, to which one could add the McGill value 2709(15) [83Ia02]; but the new doublets implicate a value 2730(10) keV, higher than all of them. Restudying the three papers mentioned, we found no reason to distrust the first two, measured with magnetic spectrometers. The third was measured with a semiconductor spectrometer; here it is noted that the error above is the one mentioned in the abstract, but that the text mentions errors of 5 and 8 keV. But even the latter does not quite cover the difference with the mass spectrometer result. This is just one example, albeit the most worrisome, of difficulties we had with the new values. Our studies, together with that of Hartmann [94Hart], led to a revision of some error values reported by the authors in ref. [80De02] and of the consistency factors (see below) of some other mass-spectrometric data. The decay energy of ^{91}Rb(β^-) has also been increased due to the feeding of the 93.628 keV level in ^{91}Sr. Nevertheless, the overall consistency of the data in the A=88–96 region leaves something to be desired.

A new experiment by the SPEG group at GANIL is reported at this conference [95Char] for proton-rich nuclides along the rp-process path, but unfortunately their analysis is not yet completed and they will not be included in the AME-95 update. Also a new method using the CSS2 cyclotron at GANIL is reported at ENAM'95 [95Lepi] and yields the first direct mass-measurement of ^{100}In with a precision of 420 keV, in perfect agreement with the value found indirectly in its delayed-proton decay spectrum [95Szer].

Last but not least, H. Wollnik for the ESR group reported the measurement of a wealth of new masses in the p-rich region around Pb. Here also alas, no values are yet available to be included in the very next update.

4.3. Partial consistency factors

In the past, we found reasons to increase errors reported for results obtained with classical mass spectrometers. This is not so for results reported with Penning trap instruments and in the AME-95 update, we will no longer increase the errors reported for them. This is also true for the new ISOLTRAP measurements on Rb and Sr isotopes: they are accompanied by some new measurements on neutron-rich Cs and Ba isotopes which agree satisfactorily with reaction and decay data. We therefore decided for the time being, to accept these Penning trap measurements as they stand, and to live with the bad consistency reported in the previous section.

We found that on-line mass measurements of the Orsay-ISOLDE group performed in the early eighties agree somewhat less than we assumed earlier with other data, due to the increased number of data that have become available since. Before, the reported errors were multiplied with a "consistency factor" of 1.5; this value now appears slightly underestimated and we found it necessary to increase this to 2.5.

Also the mass measurements of the St-Petersburg group with the PRISM spectrometer [89Al33], performed until now only for 7 isotopes of Rb, do not agree well with other data, exhibiting a systematic deviation, with an overall discrepancy of 4.01. The calibration procedure in which elements (Zr, Nb, Mo) different from the measured Rb were used, may have resulted in different ionization locations in the source and may be a reason for such an effect. No other measurements with the same spectrometer have been reported since then. The necessary PCF of 4 is such that these data are outweighted by the ensemble of all the other ones.

5. New reaction and decay data

Whereas mass-spectrometric data almost always yield experimental values for masses, it is not always so for energy measurements from decays or reactions. The reason is that it often occurs that both parent and daughter nuclides in the first case, or target and residual nuclides in the second, have unknown masses. Therefore if a later experiment determines the mass of one of them, the other one is determined at the same time. A somewhat excellent example can be found in the determination of the isomeric excitation energy of ^{181}Os by the ISOCELE group [95Rous]: the mass of the excited isomer beeing known from its β^+-decay, not only the ground-state mass of ^{181}Os is now known, but also the masses of ^{185}Pt from its α-decay to the latter, of ^{185}Au from its β^+-decay and of its α-daughter ^{181}Ir.

Among the newly (since the AME-93) measured ground-state masses, one may note nuclides beyond the neutron drip-line (^{10}He and ^{16}B) by groups at RIKEN and at HMI, or beyond the protron drip-line (^{105}Sb) by the Berkeley group; and also a very neutron-rich nuclide (^{154}Nd) at Idaho, and proton-rich ones (^{86}Mo, ^{100}In, ^{137}Sm, ^{139}Eu, ^{207,208}Ac, ^{211}Th, ^{213,214}Pa, ^{219}U and ^{228,229}Pu) by groups at Kyushu, Leuven, Dubna, Jyväskylä (with RITU) and GSI. This list covers the communications we received before the ENAM'95 conference, and may be extended before the AME-95 update is completed.

Important information is also brought, as stated above, by new data not connected to known masses. Such is the case of the proton decay of ^{112}Cs (Daresbury), the β^+-decay of ^{134,135}Pm (Dubna) and the α-decay of ^{172}Au (Daresbury). Also, in the region ($Z \geq 82, N \leq 126$), where not so many masses are known, the several α-decay energies measured at RITU help map the region; they are milestone awaiting connections to the backbone of masses.

Some very heavy nuclides and more especially new elements (see section 3) have been identified and their half-lives and α-decay energies determined. With few exceptions the observed α lines are not connecting ground-states, but they still give useful information in getting good estimates of the Q_α energies and masses of the heaviest nuclides.

5.1. Gamma-ray recalibration

The mass spectrometric result on ^{15}N reported by the MIT group [94DiFi] (see section 4.1) is of importance for the calibration of γ-ray energies. The change due to this result is rather larger than the error reported for the 1975 [75Sm02] value. The latter comes from notes on only one measurement left after the death of Lincoln Smith and the deviation is therefore not so surprising. Recent measurements on the ^{14}N(n,γ)^{15}N reaction by an Oak Ridge-Los Alamos group [94Jurn] confirm the new value. It will lead to a recalibration of γ-rays in precise (p,γ) and (n,γ) reaction energies. On average, the energies will be increased by about 6 ppm. This, however, will not be attempted before the 1995 update.

5.2. Proton emission

Several new cases have been investigated by groups at Berkeley, Daresbury and Garching. An older result on ^{121}Pr, not included in AME-93, was a reason to add a number of estimated mass values between this nuclide and those given in [I]. In the estimates from trends in systematics, proton decays are often quite useful in changing extrapolations into interpolations!

Noteworthy is the newly reported proton energy of ^{112}Cs which is smaller than that in ^{113}Cs, contrary to the normal increase with decreasing neutron numbers, probably reflecting a stronger neutron-proton pairing energy. Such inversion is also observed for ^{108}I for which an upper limit of 500 keV is reported for the energy of the emitted protons. Moreover, in the latter case, since this energy must be positive, we represented this result as a measured value.

5.3. Other decays and reactions

Since the AME-93 new α-energy measurements have been performed by groups at Leuven, Oak Ridge, Daresbury and Orsay. The number of new results on β-energy measurements from groups at Notre-Dame, GSI, Idaho, Dubna, Jyväskylä, Buenos Aires, and elsewhere is also quite impressive. At the same time, some β^--decay data have been revised (see e.g. section 7) often following a better knowledge of the decay schemes, or their errors have been re-evaluated (see e.g. section 4.2). They will appear in the AME-95 update.

Quite important are the very precise differential reaction energies performed at Heidelberg on ^{40}Ar, and by the Tübingen-Indiana group on Hg isotopes. Also, thermal neutron capture γ-decays, that provide some of the most precise data, have been reported by groups at ILL and Latvia, for Ni and Ba isotopes.

5.4. Final levels in α-decay

In α-decay, the energy of emitted α-particles is usually measured with good accuracy. For nuclides with an even number of protons and of neutrons, the strongest branch always goes to the ground-state of the daughter. Unfortunately, this is not so for other nuclides and in many cases the level energy fed by the observed α-ray is not known. One then has only a lower estimate of the decay energy (except of course when the observed α-ray originates from an upper isomeric level).

In the region of deformation, where the Nilsson model holds, the "favored" and often most intense α-decay of an odd mass nuclide feeds the level in the daughter with the same Nilsson model quantum number assignment as in the parent. Mostly, this is not the ground state. For the region above A=225, we noticed already for our 1993 mass evaluation that the distances between Nilsson particle levels in known cases did not vary greatly. We therefore made estimates, based on these systematics, of excitation energies of final levels in cases where they were not observed. In this way, we derived what we judged to be good estimates for the α-decay energies in such cases (see [95Waps]). The values computed with the help of such estimates (and, for the rest, with purely experimental results) were indicated with a special symbol (*) different from that used for systematics (#). This policy will be generalized in the AME-95 update.

Unfortunately, the systematics of Nilsson assignments to nuclides with odd numbers both of protons and neutrons is more complicated. We did not try to make a similar analysis for them. A first review of the deformed region A=155–185 seems to indicate that extrapolations of excitation energies of Nilsson levels are less dependable here.

5.5. The ^{10}Li ground-state mass

The important question of which state is the ground-state often occurs in the mass evaluation. An example is given by ^{10}Li, which is unbound to particle emission and whose states are observed as resonances. Masses have been measured in recent experiments at MSU [94Yo01] and at HMI [95Bohl]. The apparent discrepancy among their results, and also with previous studies, are due to the different selectivities of the reactions used. The mass measured by [95Bohl] at 240(60) keV above the one neutron threshold unambiguously corresponds to a 1^+ state with the configuration of a $1p^{1/2}$ neutron resonance coupled to the $3/2^-$core of ^{9}Li. The main peak seen at MSU [94Yo01] at 540(60) keV correponds to a p-wave neutron resonance, and thus most probably to the 2^+ state of the same configuration, while a much weaker 'non-conclusive' peak that would correspond to an s-wave resonance might be observed at a lower mass, less than 100 keV above threshold.

Combined results of two other experiments, at MSU [93Kryg] and at GSI [95Zins], give strong evidence for an s-wave strength rising towards the threshold that could be interpreted as a final state interaction without the character of a resonance, or as a true resonance. In the latter case it would be most probably a 2^- state.

We accept here, provisionaly and until improved measurements are performed, the proposal of P.G. Hansen [95Hans] based on the GSI result of a true resonance with an excitation energy below 50 keV, corroborating the weak peak of Young [94Yo01]. The user of our tables should however keep in mind that the resulting adopted value for the ground-state mass of ^{10}Li is not final and that in the case where the s-wave strength near the threshold should be later proved not to be a resonance, the ground-state mass would be some 200 keV higher.

5.6. ^{99}Rh isomers

A new publication [94Kuma] confirms an earlier one of [69Ph01], that the 4.7 h $9/2^+$ isomer in ^{99}Rh is 64.3(.4) keV above the 16.1 d $1/2^-$ one. For this reason we restudied the available publications on the decay of the latter one, for which we first accepted the [74An23] conclusion that its decay energy is larger than that of the former; the data of [59Town], given only in an abstract, we trusted less. Considering now their rather extensive γ-β coincidence data in combination with the modern decay scheme [NDS], we noticed that the decay energies calculated from the four [59Town] β-branches agreed excellently and that the lower branches found in the singles β-spectrum by [74An23] must be considered mixtures and therefore should be given little weight. A happy consequence of the resulting changes is that some earlier bad agreements with other data almost disappear.

It is interesting to note that the J^π systematics (see section 6) of ground-states and excited isomers for odd-Z, even-N nuclides in this region do not show a preference for either of the two alternatives for the ^{99}Rh isomers.

6. Treatment of excitation energies of isomers

The excitation energy of an isomer is derived either from internal energy relations, most often a γ-decay or a combination of γ energies, or from external energy relations, like particle decays or reaction energies. Whereas the nuclear structure evaluators are the most qualified to give values for the excitation energies of the first category, the AME can best give values for the second. Up to now we were interested only in those isomers which were essential in deriving the ground-state masses: those were the cases where experimental data allowed determination of the masses of both states. If the excitation energy of the upper level was known from γ-ray measurements, its combination with the mass of the upper level lead to a more accurate value of the mass of the ground state. If not, the data mentioned presented the best available estimate of the excitation energy of the upper isomer.

Our present policy, discussed with ENSDF evaluators, is to include in our evaluation all isomers for which the excitation energy is not derived from γ-ray measurements, and also those for which the precision in γ-ray measurements is not decidedly better than that of particle decay or reaction energies leading to them.

Also, to be consistent, those very precise excitation energies derived from γ-energy measurements should be treated in the AME as any other level entering a reaction or a decay relation, i.e. their value should be added to or substracted from the measured energy to yield a ground-state to ground-state energy. Our general policy in averaging energy lines of different levels (in the same decay or reaction and in a given experiment) is to assign to the average the error of the most precise item, instead of the error on the average, provided these errors are not dominated by statistics. This avoids giving an over-optimistic result for that decay or reaction. The new treatment of the very precisely known isomeric excitation energies permits us to apply the above policy to them also and thus to repair a slight defect in the previous evaluations.

6.1. Uncertain assignments for isomers

In some cases the value determined by the AME for the isomeric excitation energy allows no decision as to which of the two is the ground-state. This is particularly the case when the uncertainty on the excitation energy is large compared to that energy, e.g.:

$E^m(^{82}\mathrm{As}) = 140 \pm 200$ keV; $\quad E^m(^{134}\mathrm{Sb}) = 50 \pm 150$ keV; $\quad E^m(^{154}\mathrm{Pm}) = 50 \pm 130$ keV

In the above examples all 3 nuclides are odd-odd where in general the trends in J^π systematics are of no help. Neither could any preference for ground-state or excited state be derived from nuclear structure data. The assignment we adopted is such that the value for E^m is positive.

Otherwise, if an ordering is indicated by nuclear structure (e.g. if one of the isomers is known to decay into the other one, or if the Gallagher-Moskowski rule for relative positions of combinations point strongly to one of the two as being the ground-state), or if a prefered ordering could be derived from the trends of systematics in J^π, we take such constraints into consideration. In the first case the distribution of probability is truncated and only its positive part is accepted. In the second case, the ordering suggested by systematics is accepted even if it may yield a (slightly) negative value for the excitation energy, e.g. -60 ± 110 keV for ^{108}Rh or -20 ± 50 keV for ^{124}In. Such systematics are still more useful for odd-A nuclides, for which isomeric excitation energies of isotopes (if N is even) or, similarly, isotones follow usually a systematic course. This allows to derive estimates both for the relative position and for the excitation energies where they are not known.

6.2. Some particular isomers

Isomers in ^{137}Pm: The possible existence of isomers may cause an uncertainty in the mass assigned to the ground-state. An example might be found in ^{137}Pm, for which Gromov et al. [95Grom] report a β^+-decay of its 2.4 m high-spin isomer. In the isotopes of this nuclide, the $11/2^-$ levels are the upper isomers. Yet, extrapolation of their level energies, and also consideration of their half-lives, suggest that it could also be the ground-state in ^{137}Pm. Moreover no isomeric activity is known for this nuclide. We treat nevertheless its data as a decay from an isomeric state located at an estimated energy of 0#$\pm$100 keV to take the above uncertainty into account.

Isomers in ^{167}Ir and in its α-daughters: Another case are the α-decay sequences starting with the two isomers of ^{167}Ir reported at this conference [95Davi]. The proton decays strongly suggest that the activities in the α-series known before belong in reality to upper isomers (except, curiously, for the final member ^{151}Tm). This leads to a revision of the ground-state masses in this series but also suggests that more of such cases must be present.

Isomers in ^{190}Re: The isomeric excitation energy value derived from differences in β^--decay energy is 210$\pm$290 keV. From nuclear structure data [NDS] it is also known that the 6^- isomeric state should lie above the 3^- level at 119.12 keV, resulting in a lower limit. Theoretical estimates reported in [NDS] give isomeric excitation energy values of 173 and 220 keV. Thus, it seems reasonable to assume an upper limit of 300 keV. From a uniform distribution of probability in the so defined allowed range 119–300 keV, we derive an energy 210$\pm$50 keV, in agreement with all of the above information.

Isomers in ^{248}Bk: In the AME-93 we considered the 1^- isomer to be the ground-state and derived an excitation energy of 20$\pm$50 keV for the 6^+ isomer, from a combination of β^- and α energies. This result does not agree with the nuclear structure evaluation [NDS] where the 6^+ state is considered as the ground-state: its long half-life (more than 9 years) places it below the 8^- state, which in turn should be below the 1^- state from the Gallagher-Moskowski rules. The excitation energy mentioned was derived from the assumption that the α-decay of ^{252}Es (spin-parity probably 5^-) feeds the high spin isomer in ^{248}Bk. It is not to be expected, though, that the ground-states in ^{252}Es and ^{248}Bk have the same Nilsson model configurations and the alpha-decay to the ^{248}Bk rather probably will feed a 5^- level above the ground state. We therefore now assume that this α-decay is followed by a transition, for which we assume a reasonable energy.

7. Regularity of the mass-surface and use of systematic trends

It is well known that the mass-surface exhibits a very regular behavior with some superimposed "irregularities". Series of irregularities that could be observed for several Z at the same N-number or for several N at the same Z-number are considered as "structures" (shell or subshell-closures, shape transitions), whereas single irregularities could be called "accidents". Among the latter are cases where the result is derived from one, two or (in one case) three measurements of the same physical quantity, all diverging from the mentioned regularity and which were not confirmed by a different method. Only these cases are concerned here. They can be considered as incentives to remeasure the masses of the involved nuclei (and of their neighbors), preferably by different methods, in order to remove any doubt and possibly point out true irregularities due to real physical effects.

Following the new policy defined in the AME-93 (ref. [I], section 4), we continue and extend our work in flagging clearly these "accidents". In AME-93, we limited this action mainly to experimental data for such cases, published in regular refereed journals. In the coming AME-95 update many data that appeared in other types of publication will be similarly included with the same special flag (data-flag 'D'). This flag allows to repeat an adjustment with them included, in order to derive the series of tables of "purely experimental data".

It worth mentioning that two cases in the AME-93 for which we could provide a better "recommended value", are withdrawn, and a third is under reconsideration. In the ^{90}Tc(β^-)-decay, combination of the work of Iafigliola et al. [74Ia01] with later data suggested that the reported

β-endpoint belongs to a mixture of transitions to the ground-state (22%) and to the 948.1 keV excited level. This removed the earlier accident. The ^{108}Mo(β^-)-decay has been confirmed by a group in Jyväskylä. It urged us to re-examine the surface of masses in this region to try to accomodate this constraint. No conclusions have yet been drawn. Consideration of the reports on the β^--decay of ^{204}Au showed that the accepted decay energy belonged to a 4 s activity whereas later only a ten times longer half-life was found connected with this nuclide. This data is now flagged 'F' and replaced by a systematic estimate.

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References

[I] G. Audi and A.H. Wapstra, *Nucl. Phys.* **A565** (1993) 1.
[II] G. Audi and A.H. Wapstra, *Nucl. Phys.* **A565** (1993) 66.
[III] C. Borcea, G. Audi, A.H. Wapstra and P. Favaron, *Nucl. Phys.* **A565** (1993) 158.
[IV] G. Audi, A.H. Wapstra and M. Dedieu, *Nucl. Phys.* **A565** (1993) 193.
[NDS] *Nuclear Data Sheets.*
[53Am08] D.P. Ames et al., *Phys. Rev.* **91** (1953) 68.
[59Town] C.W. Townley et al., *Bull. Am. Phys. Soc.* **4** (1959) 366.
[69Ph01] M.E. Phelps and D.G. Sarantes *Nucl. Phys.* **A135** (1969) 116.
[73Ha11] J.K. Halbig et al., *Nucl. Phys.* **A203** (1973) 532.
[74An23] N.M. Antoneva et al., *Iz. Ak. Nauk. SSSR, ser. Fiz.* **38** (1974) 1748.
[74Ia01] R. Iafigliola, S.C. Gujrathi, B.L. Tracy and J.K.P. Lee, *Can. J. Phys.* **52** (1974) 96.
[75Sm02] L.G. Smith and A.H. Wapstra, *Phys. Rev.* **C11** (1975) 1392.
[80De02] R. Decker et al., *Z. Phys.* **A294** (1980) 35.
[83Ia02] R. Iafigliola, M. Chatterjee, H. Dautet, J.K.P. Lee, *J. Chem.* **61** (1983) 694.
[89Al33] G.D. Alkhazov et al., *Iz. Ak. Nauk. SSSR, ser. Fiz.* **53** (1989) 2089.
[93Borc] C. Borcea and G. Audi, *Rev. Roum. Phys.* **38** (1993) 455.
[93Kryg] R.A. Kryger et al., *Phys. Rev.* **C47** (1993) 2439.
[94DiFi] F. DiFilippo et al., Proc. ICAP-14, Boulder, 1994, p.149 and private comm.
[94Hart] H. Hartmann, Th.-Mainz, 1994.
[94Jurn] E.T. Jurney et al., Private communication to A.H. Wapstra, June 1994.
[94Kuma] V.R. Kumar et al., *J. Phys. G: Nucl. Phys.* **20** (1994) 441.
[94Laza] Yu.A. Lazarev, et al., *Phys. Rev. Lett.* **73** (1994) 624.
[94Yo01] B.M. Young et al., *Phys. Rev.* **C49** (1994) 279.
[95Bohl] H.G. Bohlen, Private communication to G. Audi, May 1995.
[95Boll] G. Bollen et al., *Nucl. Phys.* **A** to be submitted.
[95Bren] D.S. Brenner, N.V. Zamfir and R.F. Casten, *Phys. Rev.* **C50** (1995) 490.
[95Char] M. Chartier et al., presented at this conference (ENAM'95, Arles, June 1995).
[95Davi] C.N. Davids et al., presented at this conference (ENAM'95, Arles, June 1995).
[95Ghio] A. Ghiorso, et al., *Nucl. Phys.* **A583** (1995) 861c.
[95Grom] K.Y. Gromov et al., Private communication to G. Audi, April 1995.

[95Hans] P.G. Hansen, Proc. Niigata Conference, November 1994, in press.
[95Hart] H. Hartmann et al., *Nucl. Phys.* **A** to be submitted.
[95Ho.1] S. Hofmann, et al., *Z. Phys.* **A350** (1995) 277.
[95Ho.2] S. Hofmann, et al., *Z. Phys.* **A350** (1995) 281.
[95Ho.A] S. Hofmann, et al., GSI-Nachr. February 1995.
[95Lepi] A. Lépine et al., presented at this conference (ENAM'95, Arles, June 1995).
[95Ogan] Yu. Ts. Oganessian, presented at this conference (ENAM'95, Arles, June 1995).
[95Raim] H. Raimbault-Hartmann et al., presented at this conference (ENAM'95, June 95).
[95Rous] B. Roussière et al., *Z. Phys.* **A351** (1995) 127.
[95Szer] J. Szerypo et al., *Nucl. Phys.* **584** (1995) 221.
[95Waps] A.H. Wapstra, to be published.
[95Zins] M. Zinser et al., Preprint GSI-95-03.