Hora, H., G.H. Miley, and K. Philberth. *Radiochemical Observations for Comparison of Uranium Fission with Low Energy Nuclear Reactions LENR*. in *American Physical Society Meeting*. 2008. New Orleans.

Radiochemical Observations for Comparison of Uranium Fission with Low Energy Nuclear Reactions LENR

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Abstract

The discovery of nuclear fission by Hahn and Straßmann was based on a very rare microanalytical result what initially could not indicate the very complicated details of this most important process. A similarity is discussed for the low energy nuclear reactions (LENR) being proved from analogies of measurements of uranium fission. The distribution of the elements with uranium fission is similar to the element distribution with LENR. This was observed repeatedly and reproducibly with high density deuteron concentration in palladium. This discussion is specifically focussed to the Maruhn-Greiner local maximum of the distribution within the large-scale minimum if the fission nuclei are excited. The consequences of the complications in uranium fission are discussed in comparison with LENR with respect to the studies of a hypothetical fissioning compound nuclear reaction via a concluded element $^{306}X_{126}$ with double magic numbers.

INTRODUCTION

Large numbers of observations have been reported indicating possible nuclear reactions when a very high concentration of hydrogen isotopes is placed in palladium and similar metals [1]. A specific reproducible result was the measurement of the generation of heavy nuclei [2] which process is called low energy nuclear reactions (LENR). A remarkable result from this is that the distribution of the generated heavy nuclei depending on the proton number Z show maxima which could be combined by a Boltzmann distribution [3]. It was a point of confirmation by consistency that this distribution permitted a derivation of the magic numbers of nuclei [4] where a threefold multiplication of a shell structure resulted, indicating a quark property within nuclei.

A further most convincing result was the observation of a local maximum in the large scale minimum of the element distribution [3,4] near the nucleon number A = 153, similar to the distribution of the fission products of uranium at 119. The local maximum for uranium was the result of the Maruhn-Greiner process if the splitting nuclei are excited to energies in the MeV range. It was concluded that the same excitation may be the reason LENR occur, if a compound nuclear reaction process [5] via an excited nucleus with A = 306 is involved [3].

We explain first how the uniqueness of the chemical analysis for extremely low quantities of barium [6] was the only proof of fission generated nuclei of medium atomic weight, while the detailed process was found to be very much more complicated, mostly including beta decays. This is the basis for the following comparison with consequences for formulating the question whether the LENR process is similarly a process in combination with beta decays or – as initially explained by a deuterium cluster process [3] – by generation of a large amount of helium-3.

THE HAHN-STRASSMANN PROOF OF NUCLEAR FISSION

It is remarkable that the discovery of nuclear fission was based only on the single chemical detection of lowest quantities of alkaline earth elements as barium. What was convincing was that the uranium before neutron bombardment had a concentration of barium very far below a minimum limit, and that a clearly detectable barium concentration was detectable after the neutron bombardment. It was understandable that the radiation physicist Lise Meitner [7] a few weeks before the publication [6] could not understand what the result of the experiment with the barium indicated. She did not believe Otto Hahn’s measurements were correct, and asked him to measure all over again, before drawing the conclusion that nuclear fission had occurred.

It was only later that the phenomenon was explained in detail, and it was understood that very complicated effects occur when a neutron reacts with U235 with subsequent emission of three neutrons. One of the numerous possibilities is the branch of reactions shown in Fig. 1, where eleven additional beta decays are involved to arrive the reaction [8]

$$^{235}U_{92} + n \ = \ ^{90}Zr_{45} + {}^{143}Nd_{60} + 3n + 199MeV + 11\beta^{-} \quad (1)$$

At this reaction branch, only the alkaline earth products are radioactive, ^{143}Ba (12s) and ^{90}Sr (29y), which may have been sufficient for detection. In other branches, longer living barium may appear, but it is always unstable and decaying. If Hahn and Straßmann [6] had checked their samples much later, the barium may have been gone due to the subsequent beta decays. Initially, this could not have been understood without knowing the complicated reaction branches of which one example is given in Fig. 1, and all kinds of suspicions could have been expressed about the initial experiments with barium detection. Such typical problems with measurements are known and it was true what Emilio Segre said: that it is really a miracle how fission was discovered leading to the well-known consequences. The only method of detection was based on the extremely precise measurement of barium, and not of any other elements, but this was sufficient to conclude that the uranium nuclei were split into those with medium atomic weight.

URANIUIM FISSION AND LOW ENERGY NUCLEAR REACTIONS

The distribution of the nuclei after fission of uranium or plutonium shows a minimum at half nucleon mass A of the initial nuclei; i.e., at a nuclear mass of 119 or next (Fig. 2) [9].

This distribution with the absolute minimum, however, refers to unexcited splitting nuclei having a very low temperature. In the case that these nuclei are excited to a higher temperature in the MeV range, the distribution is changed, having then a local maximum at the mentioned absolute minimum of the unexcited state. The analysis based on the drop model of nuclei fully reproduced this local maximum as it was shown by Maruhn and Greiner [10]. These calculations are based on collective mass parameters from the BSC formulation where the parameter λ of the length in the Schrödinger equation for the splitting of heavy nuclei follows the models of nuclear molecules [11] has to be fit according to the theory of fragmentation dynamics in nucleus-nucleus collisions [10].

Figure 3 shows the resulting fission mass distribution for ^{236}U for the elongation $\lambda = 1.8$ at different excitation temperatures of the splitting nucleus. It is significant that the initial absolute minimum near A = 119 receives a local maximum if the nucleus is excited to 1 or 7 MeV temperature before fission.

This result is very important for the comparison with LENR experiments. Fig. 4 shows the generation of nuclei [2] in palladium after incorporation of deuterium in a reproducible way after a reaction lasting several weeks. The line follows a Boltzmann distribution of the measured maxima [13]

$$N(Z) = N' \exp(-Z/Z') \tag{2}$$

where Z' had to be 10. Other numbers for Z' (9 or 11) did not fit. This is especially important for the following consequence for the new kind of evaluation of magic numbers. This same distribution (2) can be seen in the standard abundance distribution (SAD) of the elements in the Universe [11] for elements above iron (see Fig. 10 of [14]).

Detailed measurements of the minimum in Fig. 4 for Z between about 50 and 80 are shown in Fig. 5 [12]. It was most significant that the minimum near A = 155, similar to the uranium fission of Fig. 2, showed an additional local maximum which could be understood as similar to the Maruhn-Greiner local maximum of Fig. 3, such that this may be due to a fission process from an excited very short lived intermediary compound nucleus which may be of A = 306.

A secondary result from evaluation of Eq. (2) based on the LENR measurements and from the SAD measurement in the Universe, is the fact [13] that the following bold magic numbers

$$M_{an} \in \mathbf{2, 8, 20}, 40, 70, 112 \tag{3}$$

$$M_{bn} \in 2, 6, 14, \mathbf{28, 50, 82, 126} \tag{4}$$

could be concluded. Bagge [15,16] had derived the sequences (3) and (4) from numerical speculation to find agreement with measurements but could not explain the jump from one to the other sequence. The procedure from the observed Boltzmann distribution (2) immediately led to an explanation for the jump. An interpretation is the well known change from spin to spin-orbit properties within the nuclei given by Jensen and Maria Goeppert-Mayer. A further consequence of the LENR-SAD evaluation [13] led to the ratios R(n) (n=1,2,3…) of the Boltzmann probabilities (2)

$$R(n) = 3^n \tag{5}$$

for the magic numbers indicating a threefold property of stable configurations at magic numbers in nuclei indicating a quark property. It was a consequence that the otherwise not certain number 126 was confirmed and new magic numbers 180, 246 and 324 could be concluded. The aforementioned intermediary short lived compound nucleus ^{306}X would be significant as having the magic numbers of 126 protons and 180 neutrons, similar to the double magic numbers 82 and 126 in the very stable nucleus ^{208}Pb. These results in retrospect to the explanation by Jensen and Maria Goeppert-Mayer may arrive at further clarification about nuclear models.

BOSE-EINSTEIN DEUTRON CLUSTERS FOR NUCLEAR REACTIONS IN PICOMETER DISTANCE

Up to this point we mentioned the convincing consistency of the measurements of LENR with respect to the measured dependence of the distribution of the generated nuclei on the proton number Z or the nucleon number A in agreement with the large scale minimum known from fission of uranium, Fig. 2 at A = 119 and A = 153 and especially with respect to the local maximum for excited nuclei at fission known (Fig. 5) form the Maruhn- Greiner theory. A further argument was the Boltzmann distribution (2) with $Z_o = 10$ leading to the derivation of the magic numbers and the quark-like 3^n-law for the probability ratios for magic numbers.

At this stage, the following more hypothetical aspects about the detailed mechanisms may be considered. Based on the measurements of Prelas et al [17] it was concluded that to understand the reaction mechanism [18] that the deuterons solved in the palladium have a screening of the Coulomb repulsion by a factor 14 compared with a factor 5 for high temperature plasmas. By comparing with the very anomalous long distance reaction distances at hot fusion and the myonic fusion, it was concluded that the reactions in palladium are occurring at distances of 2 to 3 pm and have a reaction time in the rough range of Ms (megaseconds). These distances and times are known also from the K-shell electron capture radioactivity. This aspect may be comparably acceptable.

A more uncertain aspect is the following consideration of a cluster mechanism of deuterons. Knowing that the deuterons are then moving as electric neutral particles like a Maxwellian gas within the palladium as long as their interaction distance is not less than 2 pm, its was calculated [3] that the 2 pm distance between the electrically neutral deuterons arrives at gravitational attraction in the range of an energy density of 0.1 eV/cm^3 what is competitive against thermal motion. If clusters about 150 of these neutral deuterons are produced, their diameter is in the range of 10 pm. Taking into account the de Broglie wave length of each deuteron in the pm range, the cluster has then the Bose-Einstein quantum state with non-distinguishable deuterons. Within about 1 Ms such a cluster moves within 2 pm distance to a palladium nucleus, and the following reaction may be possible

$$^{108}Pd_{46} + 156\,D = {}^{306}X_{126} + 38\,{}^{3}He_2 + E \tag{6}$$

Expressing the mass per nucleon m_X by proton masses in X to arrive at

$$m_X = 1.004946 \text{ minus the relative part of E,} \tag{7}$$

this mass is not unexpectedly high compared to the very low value m_{Fe}=0.9988376 with the value of m_U = 1.0001868 when splitting into ^{121}Sb with m_{Sb} = 0.99824. The comparable values to look for are from the splitting of the compound nucleus X into ^{153}Eu with m_{Eu} 0.9988375. The energy per nucleon in $^{306}X_{126}$ is 5.73 MeV minus the contribution going into the reaction energy E. Obviously the energies involved are of reasonable values for this compound nuclear reaction process [5]. If the double magic number intermediary compound nucleus $^{306}X_{126}$ would be in the range above seconds, it should be detected by the very energetic K-shell x-ray emission.

Since the clusters have an enormous specific weight due to the very high density, one may assume that this could be checked if the reaction is favoured by surface plasmons since the clusters would be drawn down by gravitation.

CONCLUSION

The distribution minima for uranium fission and for LENR at A = 119 and 153 respectively and the local Maruhn-Greiner maxima for fission from excited states were obvious from the measured properties. The question still remains whether a fission process similar to that of Eq. (1) for uranium happens with inclusion of several beta decays, or whether the fission process at LENR is without the beta processes as given by Eq. (6). It was most remarkable that the long duration LENR process resulted in stable nuclei [10] with almost no subsequent radioactive emission.

Nevertheless it has to be taken into account that the measurement of Prelas et al [17] showed several gamma lines even of energies above 20 MeV. This may indicate that the LENR generation of the heavy nuclei from the very high density screened deuterons in palladium may be much more complicated than expressed by Eq. (6), in a way similar to the rather simplified fact of the barium detection with uranium fission [6] was only the first step to understanding very complicated details of nuclear fission.

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Figures

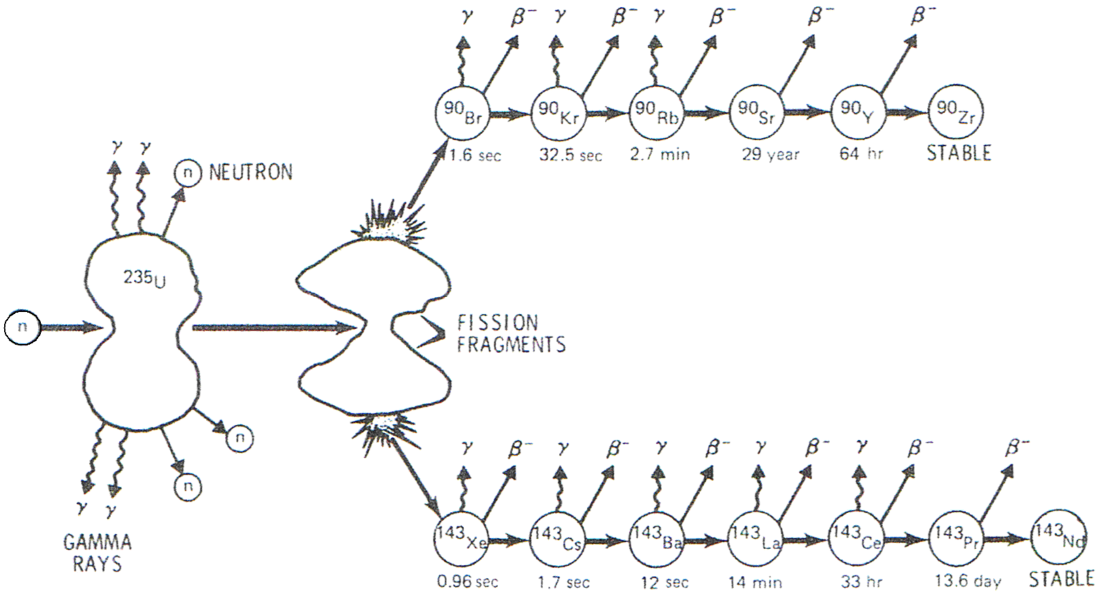

Fig. 1 Reaction of a neutron with ^{235}U leading to a branch with 11 beta decays until stable nuclei are being produced [8]

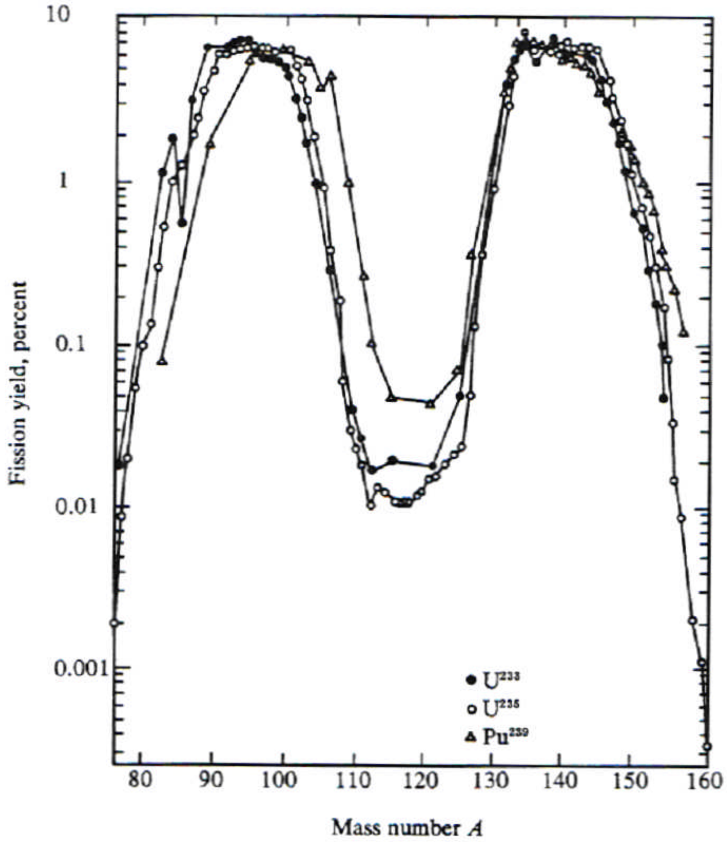

Fig. 2 Fission mass distribution curves as measured for ^{233}U, ^{235}U and ^{239}Pu [9]

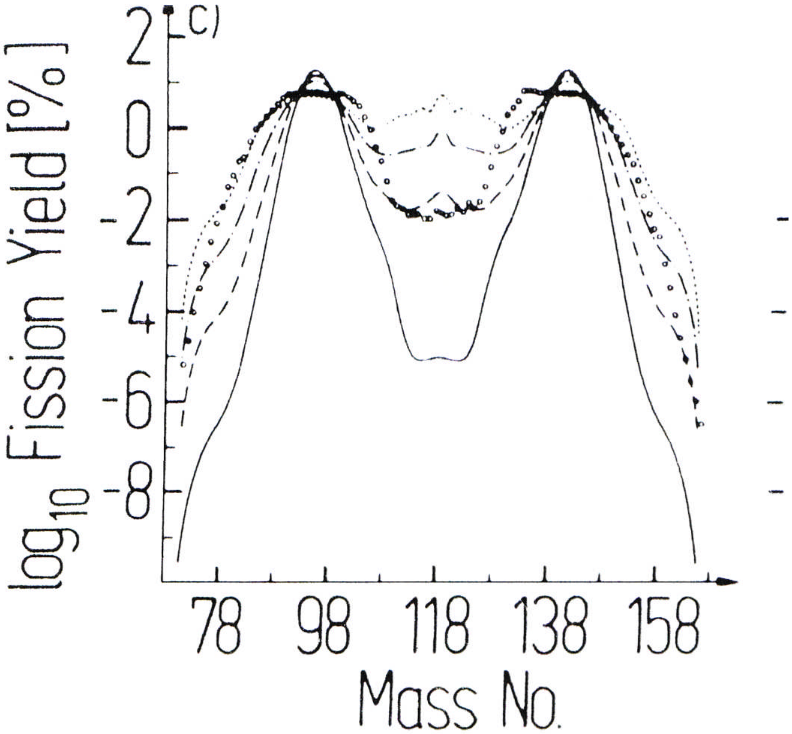

Fig. 3 Fission mass distribution curves for ^{236}U calculated if the nucleus at the time of fission is excited to a temperature 0, 0.5, 1, and 7 MeV (upward sequence of plots) for the length paramter $\lambda = 1.8$ in the Schrödinger equation [10].

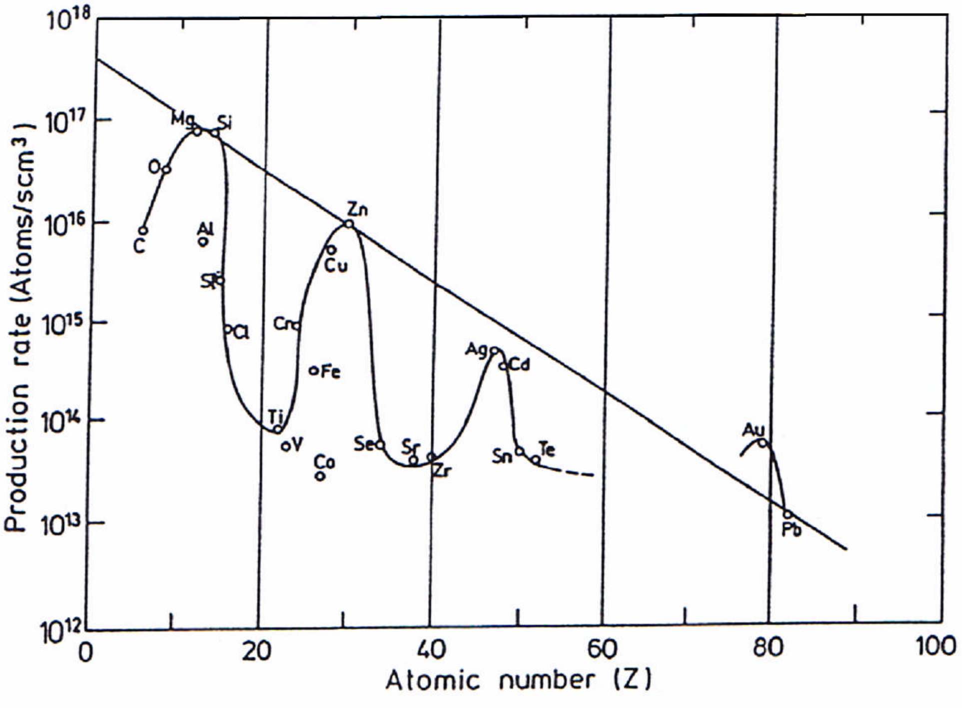

Fig. 4 Measured [3] production rate at LENR of nuclei depending on their proton number by LENR. The line represents a Boltzmann distribution, Eq. (2).

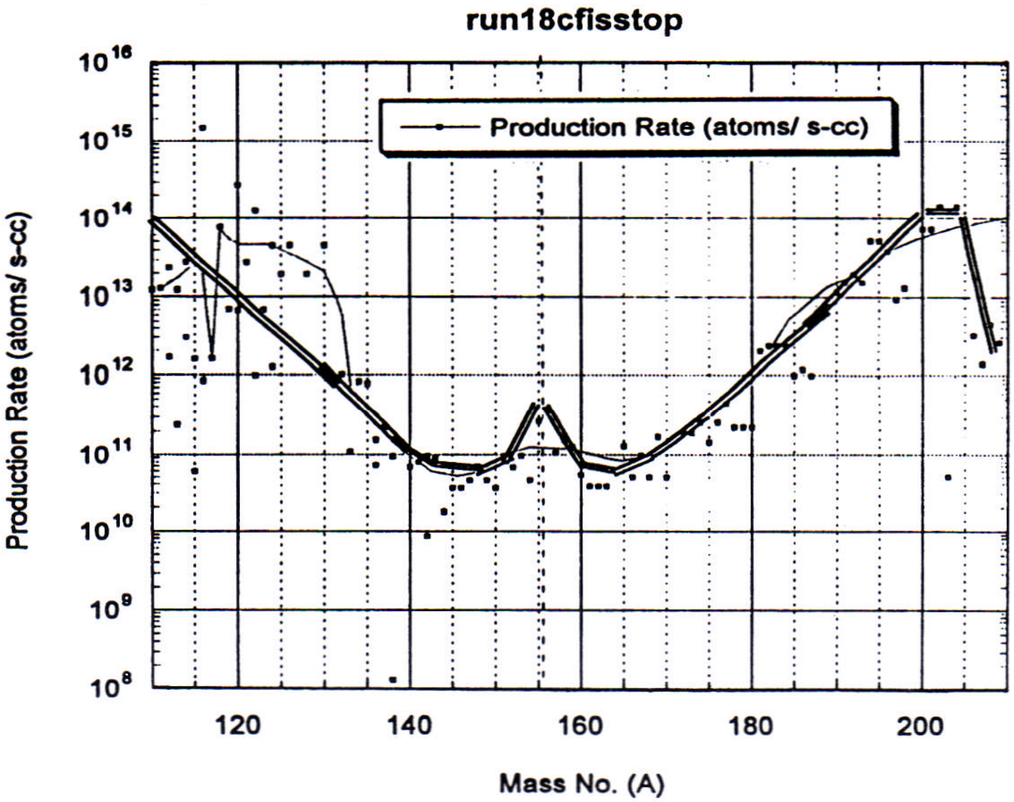

Fig. 5 Detailed nuclear mass spectrum of the LENR generation probability at the highest-Z minimum of Fig. 4.