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PERIODIC LAW OF ATOMIC NUCLEI. ISOTOPES AT END OF THE PERIODIC SYSTEM

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The discovery of the periodic system of atomic nuclei (1) has enabled us not only to predict isotopes which have not yet been found and to define their properties, but also to predict elements following after the known No 96, Cm.

It became possible to indicate the mass of nuclei which have been predicted, to characterize them with respect to their decay period, energy, type of emitted radiation, and other nuclear properties, and to select, tentatively, reactions for their isolation.

The present communication aims to show that the regularly changing properties of nuclei in the periodic system demonstrate that elements No 97, 98, 99, and 100 must have nuclei, the half-life of which can be measured in years. Consequently, the elements in question ought to be susceptible to synthesis and investigation within a not too distant time. It also appears that more stable unknown nuclei of the known elements At (astatin), Rn (radon), Fr (francium), Pu (plutonium), and others must exist and be the principal isotopes of these elements.

Many isotopes at the end of the periodic system of atomic nuclei apparently remain undiscovered. They definitely must have existed under the conditions of the genesis of elements and consequently can be discovered and synthesized. In the appended graph, we have indicated by triangles 142 nuclei of isotopes which, without any doubt, exist or must have existed.

Isotopes of elements at the end of the fourth period up to Ra and elements of the fifth period continued after Cm up to Z = 100 have been plotted in the coordinate system Z/A - A, as shown in the graph.

The properties of atomic nuclei change in a regular manner along each isotope curve (from left to right) separately for even and odd values of Z. Within the limits of the isotope period of each element, (from top to bottom) a similar regular change of nuclear properties takes place, separately for even and

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odd masses, corresponding to a certain value of Z. Regular changes of nuclear properties also occur along diagonals of the graph. For example, it is known that nuclei situated along a diagonal even Zs, even masses - odd Zs, odd masses will be more stable than those disposed along a diagonal even Zs, odd masses - odd Zs even masses.

Thus, the periodic system of atomic nuclei enables one not only to predict the existence and to forecast the properties of istopes which have not yet been discovered, but also to verify these assumptions by comparing the results obtained for a certain isotope in tracing the changes of nuclear properties, e.g., first along the isotope curve and then along the isotopes of the element in question, the isobar upright, etc. We have shown in the graph all points corresponding to known isotopes (2), indicating the type of emitted radiation and the half-life in the case of radioactive nuclei.

Stable isotopes of the greatest relative occurrence are indicated by circles, while the most stable radioactive isotopes are indicated by squares.

Triangles indicate predicted isotopes, and triangles containing a square the most stable predicted isotopes.

A study of the isotope curves in the graph shows that the period of nuclear decay (stability of nuclei), in the fifth period after Ra, first increases from the left to the right for even Zs along each isotope curve until a maximum is reached, and then drops in a regular manner. The same occurs with reference to the odd Zs of each curve.

In passing to a higher number of the isotope curve (from top to bottom), it can be observed that the maximum of nuclear stability gradually moves from left to right. This indicates the existence of the most stable nuclei of the last elements in the lower right-hand corner of the graph.

Let us show on the examples of the unknown nuclei U^{236} and Pu^{242} that these nuclei have a very slow period of decay. U^{236} is shown in the graph on the isotope curve $j = 52$, which depicts nuclei having an even mass. In view of the fact that U^{236}_{92} has an even Z, let us trace the variation of τ along $j = 52$ for nuclei having an even Z. It follows from the graph that the τs corresponding to even Zs of the isotope curve $j = 52$, and the τs corresponding to even masses of the uranium isotope period have the following values:

For $j = 52$

Z	88	90	92	94
τ	6.7 yr	1.39×10^{10}	?	6000 yr

For $Z = 92$

A	228	230	232	234	236	238
τ	9.3 min	20.8 da	70 yr	2.35×10^{5} yr	?	4.5×10^{9} yr

Consequently, the half-life of a U^{236} nucleus must be shorter than 1.39×10^{19} years and longer than 6,000 years, and, on the basis of data on uranium isotopes, at the same time fall into the interval between 2.35×10^5 years and 4.51×10^9 years. Even this semiquantitative treatment indicates that the hypothetic nucleus U^{236} must have a half-life of at least 10^6 years.

Similarly, a conclusion can be reached to the effect that the most stable nuclei of Pu are the still unknown nuclei Pu^{242} and Pu^{244}, and that one of the latter is the principal isotope of plutonium.

We can see that the most stable nuclei of the isotopes Ra^{226}, Th^{232}, and U^{238}, the masses of which differ by six units, follow the law

$$j_{z+2} = j_z + 2$$

similarly to the principal isotopes in the region In, Sb, I. Cs, which we have described (1).

If the stability of isotopes of elements No 97, 98, 99, and 100 is estimated by extrapolating according to isotope curves and isotope periods, the conclusion is reached that the isotopes of these elements which lie on the curve $j = 53$ have a half-life of the order of many years. For instance, a high stability must be ascribed to the nuclei 97^{247}, 98^{250}, 99^{251}, and 100^{254}.

The type of emitted radiation and other properties can be predicted for isotopes of elements No 97-100. In accordance with the rule that K-capture in the case of nuclei with an even j always occurs when Z is odd, and that in the case of nuclei with an odd j it always occurs, no matter whether Z is even or odd, one may expect that the isotopes 97^{241}, 97^{242}, 98^{243}, 99^{245}, 99^{246}, and 100^{247} will exhibit K-capture. One must also assume that the nucleus 98^{250}, to give an example, will exhibit α-decay without K-capture.

The absence of elements At-Fr in nature becomes understandable, because the isotopes of these elements complete the fourth nuclear period (before Ra) and must have a half-life measured in hours and minutes.

It is obvious that the most stable isotopes of At, Rn, and Fr are not At^{210}, Rn^{222}, and Fr^{223}, which are known at present, but the normal nuclei At^{209}, Rn^{212}, and Fr^{213} lying in their own (fourth) structural period. The latter are the principal isotopes of the elements in question. The fact that Fr^{223} emits β^--radiation definitely indicates that the principal isotope is Fr^{213}.

We have indicated some of the conclusions resulting from a consideration of the isotopes appearing at the end of the periodic system of atomic nuclei. The importance of the periodic system in research on this subject is obvious.

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/Graph follows:/

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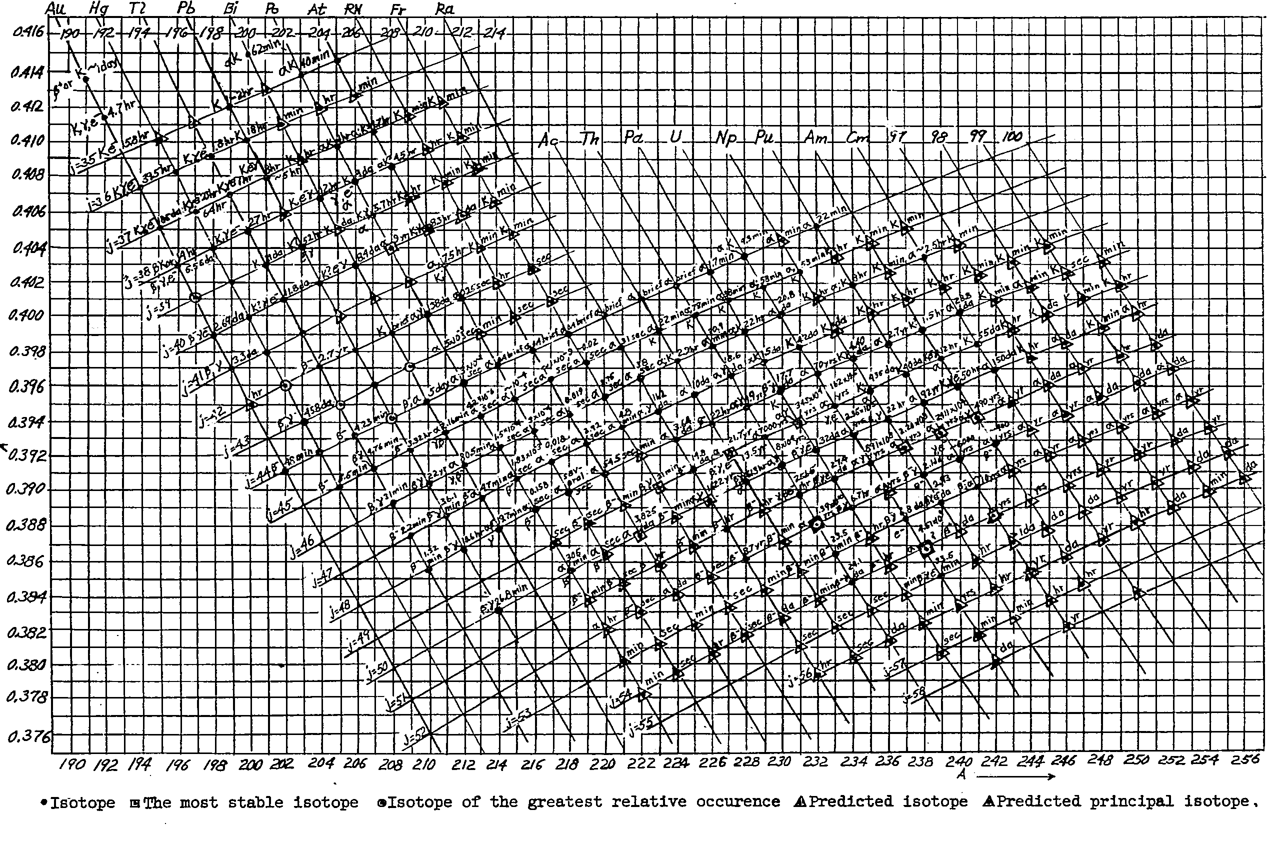
SYSTEM OF NUCLEI OF ISOTOPES (End of System)



•Isotope ■The most stable isotope ◉Isotope of the greatest relative occurence ▲Predicted isotope ▲Predicted principal isotope.

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