Nuclear Data for Science and Technology (1988 MITO), 911- 913, Copyright © 1988 JAERI.

THE SYSTEM OF NUCLIDES

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Abstract: According to the difference in the compositions of various atomic nuclei, more than 2250 kinds of atomic nuclei have been discovered. Several millions of nuclear characteristic parameters have been obtained from experiments. By comprehensively investigating the characteristics of nuclides and the compositions of atomic nuclei, can we get a systematic understanding of various atomic nuclei? The new chart---"valley-like" chart of nuclides is the answer to this question and it's the basis for further study as well.

I. New sequences.

In the new chart, all the nuclides can be arranged in a few sequences which are long, straight, parallel and horizontal.

1. The middle sequence.

Among all the horizontal sequences, the one with $^{1}H_{0}$ is called the middle horizontal sequence.

At present, there are 259 nuclides in the middle horizontal sequence, about 11.51% of all the nuclides that have been discovered (2250 all together). Among these 259 nuclides, there are 246 β-stable nuclides including 195 stable nuclides, 94.48% and 75.29% of all the nuclides in the middle sequence respectively.

2. Near horizontal sequences and the main body.

A. Near horizontal sequences. The four horizontal sequences that are close to and situated on both sides of the middle sequence are called near horizontal sequences. There are 76 radiative nuclides in the four sequences with their half-life between 1 hour and 1 year, 92.43% of this kind of long-lived radiative nuclides (515 all together) . The four near horizontal sequences are the main area where the important long-lived radiative nuclides are distributed.

B. Main body. The middle horizontal sequence and the four near horizontal ones now consist of 1260 nuclides, including all the stable nuclides, all the β-stable nuclides and all the radiative nuclides with their half-life longer than or equal to 1 year. Over 250 radiative nuclides with different half-lives now commonly used in the field of science and technology are located in these five horizontal sequences. Among all the sequences of this chart, the middle horizontal sequence and the four near ones are of the greatest significance in terms of both theory and practice, and they are the main body of the new chart of nuclides.

3. Far horizontal sequences.

All the horizontal sequences outside the main body are called far horizontal sequences. At present, they are composed of about 990 radiative nuclides. The unit of the longest half-life of some nuclides in the far horizontal sequences is day (only three of them all together). The unit of half-life of 40 nuclides is hour. The rest 947 nuclides are those with short or very short half-life.

The far horizontal sequences are the main area where the nuclides that have not been discovered are located.

II. New sequences and the compositions of nuclides.

The new sequences embody the unified and regular relation of various compositions of nuclides. In the sequence ($^{1}H_{0}$ is at the starting point and $^{259}_{100}Fm_{159}$ is at the end of the sequence. Between the two nuclides, there are altogether63 nuclides arranged in an increasing order of value A) consisting of β-stable nuclides with odd-Z (the number of protons), interpolate nuclides to make Z and A (the number of neutons) of the sequence of nuclides increase respectively in an order of natural number, 183 nuclides with even-Z, which are derived from the interpolation, must be the nuclides with the smallest ground-state atomic masses for each A, i.e. they are β-stable nuclides with even-Z. 13 nuclides with odd-Z, which are derived from the interpolation, are the ones with the third smallest values of masses for each A. The whole sequence of nuclides formed by the interpolation constitutes the middle horizontal sequence in the new chart. Obviously, according to the gradual change of nuclides with same values of A but different values of Z, other horizontal sequences of nuclides can be formed by extending from the middle horizontal sequence to both sides of the chart.

The simple but certain relation between the compositions of β-stable nuclides with odd-Z and even-Z is the decisive factor in establishing the new sequences and the new chart.

III. New sequences and the characteristics of nuclides. Of all the complicated and various parameters of nuclides, ground-state atomic mass is the most basic one that every nuclide possesses and differs from each other. This parameter as a whole changes in a valley-like shape of

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Note: According to the difference in the characteristics of nuclides, there are about 2755 atomic nuclei.

which $^{1}_{1}H_{0}$ is the lowest point and the middle horizontal sequence is the bottom line. This kind of systematic feature shows that all nuclides can be divided into three categories:

(i). "Equal" number of protons and neutrons type. The basic feature of thid type is β-stable.

(ii). Proton-"rich" type. The basic feature is β^{+}(EC)-decay.

(iii). Neutron-"rich" type. The basic feature is β^{-}-decay.

Other features superimposed on these three categories are: 1. The "stable" feature only exists in the main body area where the value of A is smaller than 210. The stable nuclides can also be divided into three types which are "equal" number of protons and neutrons type, proton-"rich" type and neutron-"rich" type. 2. α-decay exists mainly in high Z and A area, and all the spontaneous fissions exist in high Z and A area. α-decay and spontaneous fission nuclides can be divided into those three categories as well.

IV. The characteristics of nuclides and the compositions of atomic nuclei.

There exists a unified and regular connection between the basic characteristics of various nuclides and the compositions of various atomic nuclei. The integral feature of the connection is that the ground-state atomic masses and the characteristics of nuclides exhibit "valley-like" changes along with the regular and strict changes of the compositions of atomic nuclei which can be derived from the values of Z and A of the β-stable nuclides with odd-Z.

V. The natural system of nuclides.

The regular relation between the characteristics of nuclides and the compositions of atomic nuclei is derived from the feature of nuclides themselves. The system of nuclides that reflects this relation is a natural system. The system of nuclides is different from the system of elements and will be different from the system of particles and the system of antinuclides. The natural system of nuclides is manifested in the form of the "valley-like" chart of nuclides.

VI. The enlightenment of the integrity.

1. Proton is the sole starting point of the system of nuclides.

2. Taking the binding energies and other characteristics into consideration, we can establish a unified model of nuclear structure based on the unified and systematic relation and the three categories.

3. The meaning of the horizontal sequences trends to become disappeared in the high Z and A area of the new chart. The area where the nuclides with pure spontaneous fission (its decay branching ratio is 100%) are widespread may be regarded as the end of the system of nuclides in the high Z and A area.

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Fig: Distribution of the important nuclides in the horizontal sequences

Fig.1

Nuclides / sequences	stable		radioactive			total
	$t_{1/2}>10^{10}y$	$10^{10}-10^{8}y$	$10^{8}y-1y$	1y-1d	1d-1h	
$P_3.P_4.P_5$·····	0	0	0	3	36	39
P_2	29	0	11	36	76	152
P_1	15	1	33	106	62	217
MID	195	2	30	9	6	242
N_1	14	3	31	76	59	183
N_2	26	2	14	15	46	103
$N_3.N_4.N_5$·····	0	0	0	0	4	4
total	279	8	119	245	289	940
	287		653			

Fig. 2