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CAPTURE OF NEGATIVE MUONS BY ATOMS IN A CHEMICAL COMPOUND

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An investigation of the relative probabilities of capture of negative muons by atoms in a chemical compound is of independent interest, and also yields information needed for the interpretation of other experiments with muons, which by virtue of various circumstances, are carried out with targets that are chemical compounds. In this connection we have carried out measurements with several compounds, data on which are listed in Table I.

It is seen from the table that in our cases the Fermi-Teller Z-law[1] does not describe satisfactorily the experiment, as was noted in many earlier papers[2-8]. If we assume the results of the experiments in which the deviations from the Z-law exceed one mean-square error to be in disagreement with the law, then at the present the experimental situation, taking our data into account, is represented by Table II.

Table I

Compound	Ratio	Experiment	Z-law
LiCl	Cl/Li	7,2±1.1	5,12
CsCl	Cl/Cs	0,57±0.03	0.34
ZnO	O/Zn	0,450±0,013	0.28
ZnS	O/S	0,55±0.11	0.54
AlCu	Cu/Al	1.20±0.05	0.26

Table II

Character of compound	Number of experiments	Z-law satisfied	Z-law not satisfied
Alloys	6	2	4
Insulators	21	5	16
Carbon compounds	4	0	4
Total:	31	7	24

An analysis of the available data shows that, compared with the prediction of the Z-law, mesic atoms of the elements which have a relatively large electron-affinity energy are produced with some preference. This tendency is illustrated by Table III, which shows the experimental results systematized on the basis of electron affinity. In

Table III

Character of compound	Data from	Compound	Ratio	φ	Tendency
Alloys	[5]	AgZn	Ag/Zn	1,40±0,44	0
	[7]	CuAl	Cu/Al	1,58±0.16	+
		CuAl	Cu/Al	1,89±0.23	+
	[8]	CuAu	Cu/Au	1,45±0.14	+
	Our data	AgLi	Ag/Li	1,29±0,36	0
		CuAl	Cu/Al	4.55±0.20	+
Insulators	[3]	Al_2O_3	O/Al	1,63±0.22	+
		CaS	S/Ca	1,00±0.25	0
	[4]	P_2O_5	O/P	2.03±0.22	+
		SiO_2	O/Si	2.26±0.15	+
		Al_2O_3	O/Al	2.50±0.22	+
		KOH	O/K	5.23±0.96	+
		KHF_2	F/K	1,79±0.25	+
	[5]	LiI	I/Li	0,89±0.11	0
	[6]	PbF_2	F/Pb	0.95±0.14	0
	[7]	BiF_3	F/Bi	1,95±0.19	+
		UF_4	F/U	1.68±0.17	+
	[8]	CuS	Cu/S	1.04±0.10	0
		Sb_2S_3	S/Sb	1,30±0.08	+
		PbS	S/Pb	1,79±0.22	+
		CuO	Cu/O	1,70±0.14	+
		Sb_2O_3	Sb/O	0,44±0.02	—
		PbO	O/Pb	2,24±0.25	+
	Our data	LiCl	Cl/Li	1.41±0.22	+
		CsCl	Cl/Cs	1.68±0.09	+
		ZnO	O/Zn	1,51±0.05	+
		ZnS	O/S	1.02±0.20	0
Carbon compounds		$C_2O_2H_8$	O/C	0,49±0.06	—
	[2]	$C_6H_4Cl_2$—I	Cl/C	0.47±0,04	—
		$C_6H_4Cl_2$—II	Cl/C	0.57±0.05	—
	[4]	CCl_4	Cl/C	0,36±0.07	—

this systematization, the relative probabilities obtained experimentally were normalized to the Z-law, and for concreteness the quantities in the numerators of the fractions were those pertaining to atoms having the larger electron affinity:

$$\varphi = \frac{p(Z_1)}{p(Z_2)} \Big/ \frac{k_1 Z_1}{k_2 Z_2}.$$

In the last column of Table III, the plus sign denotes those experiments in which $\varphi > 1$, with the deviation of φ from unity exceeding one rms error; the zero sign denotes experiments in which $\varphi = 1$ within the limits of errors, and the minus sign denotes experiments with the opposite tendency. Data on the electron affinities of the atoms were taken from the handbook (see [9]). As can be seen from the table, only in five out of 31 cases is the tendency to preferred formation of the mesic atom of the element with the larger electron affinity violated.

One exception is Sb_2O_3, where there are no reliable published data on the electron affinity of antimony, and it is therefore not excluded that the deviation is accidental. Violation takes place for four carbon compounds, which apparently is connected with the very complicated spatial configuration of these molecules.

The measurement procedure and also a detailed discussion of the results will be published later.

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CAPTURE OF NEGATIVE MUONS BY PURE CHROMIUM AND NICKEL ISOTOPES

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THE interaction between a negative muon and a complex nucleus can be approached from two points of view: 1) if the structure of the nucleus is known, the interaction between the muon and the nucleus can help determine the interaction constants; 2) if we know the constants of the interaction of the muon with the nucleus, the muon can be used as an instrument for the study of the structure of the nucleus.

It seems to us that it would be of interest for nuclear physics to obtain data on the capture of muons by nuclei with closed neutron or proton subshells. We used such nuclei in the form of isotopes of Cr with mass numbers 50, 52, 53, and 54, of which Cr^{52} has a closed neutron subshell; a closed proton subshell occurs in nickel isotopes with mass numbers 58, 60, and 62. We present below data on the enrichment of these isotopes (in %):

Cr^{50}	Cr^{52}	Cr^{53}	Cr^{54}	Ni^{58}	Ni^{60}	Ni^{62}
90.3	99.5	84,0	78,5	97,9	96.8	89,0

A muon beam from the JINR (Joint Institute of Nuclear Research) synchrocyclotron was used for the experiments.

The total probability of muon capture was determined by measuring the lifetimes of the muon on the K orbit of the atom of the corresponding element. We present the experimental results obtained by processing the corresponding time distributions with a computer:

Nucleus	Cr^{50}	Cr^{52}	Cr^{53}	Cr^{54}	Ni^{58}	Ni^{60}	Ni^{62}
capture rate, 10^5 sec^{-1}	38,25 ± 0.50	34.52 ± 0.47	32.97 ± 0.45	30.57 ± 0,42	61.10 ± 1.05	55.62 ± 0,97	47.16 ± 0,95

A detailed description of the results and of the measurement procedure will be published later.

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