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Preceding Summary Reports:

ANL-6146 - April, May 1960
ANL-6169 - June, 1960
ANL-6190 - July, August 1960

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FOREWORD

The Summary Report of the Physics Division of the Argonne National Laboratory is issued monthly for the information of the members of the Division and a limited number of other persons interested in the progress of the work. Each individual project reports about once in 3 months, on the average. Those not reported in a particular issue are listed separately in the Table of Contents with a reference to the last issue in which each appeared.

This is merely an informal progress report. The results and data therefore must be understood to be preliminary and tentative.

The issuance of these reports is not intended to constitute publication in any sense of the word. Final results either will be submitted for publication in regular professional journals or, in special cases, will be presented in ANL Topical Reports.

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I. EXPERIMENTAL NUCLEAR PHYSICS

I-11-25 Installation and Operation of the Van de Graff Generator (51210-01)

Jack R. Wallace

This report covers the operation of the Van de Graaff generator in the Physics Division for the period from January 1 to June 30, 1960 inclusive.

The generator was used to accelerate protons and deuterons. The generator voltage varied from 1.8 Mev to 3.5 Mev. Beam currents measured at the target varied from 2.0 to 30.0 μ amp.

The following list shows the type of experiments performed with the generator and the number of hours the generator was operated for each experiment.

1. Calibration of ZGS chamber	Simanton	343.7 hr .
2. Total neutron cross sections in kev region	Hibdon	340.7 "
3. Irradiations of Mossbauer samples	Hanna, Preston, Wexler	135.0 "
4. Measurement of efficiency of neutron counting system	Mooring	293.6 "
5. Neutron polarization	Elwyn, Lane	352.0 "
6. Checking neutron monitor counters	Anderson	33.5 "
7. Ti^{48} (d,p) proton polarization	Smither, Weinman	174.1 "
	Total	1672.6 "
Startup and daily maintenance		85.0
Machine repairs and experimental setup		626.4
Total time available (127 days $\times$ 16 hours + 44 days $\times$ 8 hours)		2384.0 "

Vacuum problems and poorly operating ion sources caused large losses in the operating time of the generator during this period of operation.

The vacuum leaks were located and repaired. New liquid nitrogen traps were installed in the main vacuum system and the vacuum system of the 90° electrostatic analyzer. The ion-source problem is one that has not been successfully solved. We have worked for some time in an effort to get reproducibility in performance between various ion sources. Some progress has been made, but there are still many unanswered questions. Two employees worked this summer on various phases of this problem. It is hoped that they will be able to shed some light on such questions as: (1) Why does the current output vary so much between sources? (2) Why do the useful lifetimes of sources vary so widely? (3) Why are we not getting higher ratios of proton beam to molecular beam?

Skidmore, Owings, and Merrill were selected as the architect-engineering firm to design the building to house our new 10-12 Mev tandem Van de Graaff generator. They have completed their Title I study (preliminary design and cost estimate). The Title II work (final construction drawings) has almost been completed.

I-31-2 Decay of ${}_{66}\text{Dy}^{166}$ (80.2 hr) (51210-01)

S. B. Burson and R. G. Helmer

This project has been terminated with publication of the results [R. G. Helmer and S. B. Burson, "Decay of ${}_{66}\text{Dy}^{166}$," Phys. Rev. 119, 788-795 (July 15, 1960)].

I-80-26

I-80-26

Molecular Beam Studies

(51210-01)

W. J. Childs, J. Dalman, and L. S. Goodman
Reported by W. J. Childs

Our investigation of the hyperfine structure of the odd-odd isotope Mn^{56} is now complete, and the following results are obtained:

$$I = 3$$

$$a = +56.3924 \pm 0.0023 \text{ Mc/sec}$$

$$|b| \leq 0.050 \text{ Mc/sec}$$

$$g_J = 2.0012 \pm 0.0001$$

$$\mu_I = +3.2402 \pm 0.0002 \text{ nm.}$$

The value quoted for the magnetic moment is subject to correction for a possible hyperfine anomaly. The first draft of a paper "Nuclear Spin and Magnetic Moment of 2.6-hr Mn^{56} " has been prepared and will be submitted to the Physical Review.

Two other papers have been accepted for publication: "Achievement of Extremely Homogeneous Magnetic Fields" (Rev. Sci. Instr.) and "Nuclear Spin and Moments of 14-hr Ga^{72} " (Phys. Rev.). In addition, the final draft of "Nuclear Spin of Ho^{166} " is being prepared for the Physical Review.

The "B"-magnet for the new atomic-beam machine has been completed and provides the designed field of 21 kilogauss at the center line of the beam. Both sections of the vacuum chamber for the new machine have been completed, and one of them has been pumped down to below 10^{-7} mm Hg. J. Berkowitz, who is cooperating with us in the design of the universal detector (electron bombardment ionizer and mass spectrometer), and J. Dalman have finished design work for the ionizer. It is hoped that considerable progress on assembly of the new machine and testing of the detector will be made during the next quarter.

I-102-17 Neutron Cross Sections by Self-Detection (51210-01)

M. W. Firebaugh, C. M. Huddleston, J. E. Monahan,
and F. P. Mooring

Reported by C. M. Huddleston

TOTAL NEUTRON CROSS SECTION OF COBALT FROM 1 Kev TO 670 Kev

Earlier measurements^{1,2} of the total neutron cross section of cobalt are suspect because of the impurity of the cobalt used for those experiments. We have repeated the measurement of the transmission cross

Fig. 1. Total measured neutron cross section of cobalt as a function of neutron energy.

section, using cobalt metal of very high purity.³ Unfortunately, the transmission of the sample was quite high (≈ 0.9) for neutron energies greater than about 150 kev. For a transmission of 0.9, the percentage error in the cross section is about 10 times as great as the percentage error in the transmission. Therefore, only the low-energy part of the results is shown here (Fig. 1).

We expect to have a series of cobalt transmission and scattering samples in the near future. At that time, we propose to undertake a more intensive study of the neutron cross section.

¹ W. F. Stubbins, Phys. Rev. 84, 902 (1951).

² C. T. Hibdon, A. Langsdorf, Jr., and R. E. Holland, Phys. Rev. 85, 595 (1952).

³ Supplied by F. Karasek of the ANL Metallurgy Division.

II. MASS SPECTROSCOPY

II-36-2 Ratio of Yields of He^{++} and He^+ Ions (51300-01)
H. E. Stanton and J. E. Monahan

This project has been terminated with publication of the results
[H. E. Stanton and J. E. Monahan, "Cross Section for Formation of Doubly-Ionized Helium by Electron Impact," Phys. Rev. 119, 711-715 (July 15, 1960)].

II-38-12 Mass Spectrometric Studies of Charged Atomic and Molecular Products of Nuclear Transformation (51210-01)
Sol Wexler

DECOMPOSITION OF CCl_3Br BY ISOMERIC TRANSITION AND BY BETA DECAY

In the fragmentation of CH_3Br by nuclear isomeric transition of 4.4-hr $\text{Br}^{80\text{m}}$, singly, doubly, and triply charged carbon-containing fragments were observed in addition to H^+ , H_2^+ and a peaked distribution of charged Br^1 . The data indicated that the methyl bromide molecule disrupted because of Coulombic repulsion of redistributed charges after internal conversion and Auger electron transitions in the Br^{80} . The measurements suggested internal transfer of one, two, or three electrons from CH_3 to Br, but the full extent of internal charge transfer before molecular rupture could not be assessed for CH_3Br because it was not certain whether the charged hydrogens were the result of charge redistribution or were formed by processes involving dissociation of singly charged polyatomic species. It was therefore desirable

¹ S. Wexler and G. R. Anderson, J. Chem. Phys. (in press).

to measure the fragmentation of a simple molecule in which all the atoms have several possible charge states, and trichlorobrommethane tagged with $\text{Br}^{80\text{m}}$ ($\text{CCl}_3\text{Br}^{80\text{m}}$) was selected for study.

In addition, the disruption of $\text{CCl}_3\text{Br}^{82}$ by β^- , γ decay was studied and the fragmentation pattern compared with that from isomeric transition of $\text{CCl}_3\text{Br}^{80\text{m}}$ as well as the mass patterns found in other beta-decay measurements. Previous investigations of the decomposition of molecules by beta decay and isomeric transition of a constituent atom revealed marked differences in the decomposition patterns initiated by the two nuclear processes,¹⁻³ but this comparison has up to now been made for the two types of decay occurring in different molecules.

Enriched (Br^{79})₂ (95.1% Br^{79}) or ordinary Br_2 was irradiated in CP-5 for suitable periods to prepare 4.4-hr $\text{Br}^{80\text{m}}$ or 35.9-hr Br^{82} . The CCl_3Br was tagged with the active Br isotope by an exchange procedure based on the one described by Miller and Willard.⁴ The active gases were then allowed to decay at low pressures in the source volume of a mass spectrometer with special constructional features¹ and the intensities of the various positively charged decay fragments measured. For $\text{CCl}_3\text{Br}^{80\text{m}}$ the intensity of each fragment was determined relative to that of $(\text{Br}^{80})^{+5}$ while for $\text{CCl}_3\text{Br}^{82}$ the ion CCl_3^+ was chosen as the comparison standard. In this way variations of source pressure and specific activity of the gas could be taken into account.

The relative intensities of the various fragments from isomeric transition in $\text{CCl}_3\text{Br}^{80\text{m}}$ and β , γ decay in $\text{CCl}_3\text{Br}^{82}$, respectively, are presented in Tables I and II. The errors listed are probable errors based mainly

² S. Wexler and D. C. Hess, J. Phys. Chem. 62, 1382 (1958).

³ S. Wexler, G. R. Anderson, and L. A. Singer, J. Chem. Phys. 32, 417 (1960).

⁴ A. A. Miller and J. E. Willard, J. Chem. Phys. 17, 168 (1949).

TABLE I. Fragmentation of $\text{CCl}_3\text{Br}^{80\text{m}}$ by isomeric transition of 4.4-hr $\text{Br}^{80\text{m}}$.

Fragment	Abundance relative to $(\text{Br}^{80\text{m}})^{+5}$	Fragment	Abundance relative to $(\text{Br}^{80\text{m}})^{+5}$
$(\text{Br}^{80})^{+1}$	0.80 ± 0.08	$(\text{Cl}^{35})^{+5}$	0.18 ± 0.02
Br^{+2}	0.25 ± 0.03	$(\text{Cl}^{35})^{+6}$	0.29 ± 0.03
Br^{+3}	0.21 ± 0.02	$(\text{Cl}^{37})^{+7}$	0.18 ± 0.03
Br^{+4}	0.29 ± 0.05	$(\text{Cl}^{37})^{+1}$	0.32 ± 0.03
Br^{+5}	1.00	$(\text{Cl}^{37})^{+2}$	0.29 ± 0.03
Br^{+6}	1.26 ± 0.10	$(\text{Cl}^{37})^{+3}$	0.22 ± 0.04
Br^{+7}	1.27 ± 0.08	$(\text{Cl}^{37})^{+4}$	< 0.05
Br^{+8}	1.02 ± 0.10	$(\text{Cl}^{37})^{+5}$	< 0.05
Br^{+9}	0.76 ± 0.12	$(\text{Cl}^{37})^{+6}$	< 0.05
Br^{+10}	0.29 ± 0.03	$(\text{Cl}^{37})^{+7}$	< 0.05
Br^{+11}	0.12 ± 0.02	$\text{CCl}_3\text{Br}^{80}$	< 0.02
Br^{+12}	0.02 ± 0.01	$(\text{CCl}_3\text{Br}^{80})^{+2}$	< 0.03
Br^{+13}	0.12 ± 0.02		
Br^{+14}	< 0.01		
$(\text{C}^{12})^{+1}$	1.41 ± 0.10	CCl_3	0.68 ± 0.10
C^{+2}	0.38 ± 0.06	$(\text{CCl}_3)^{+2}$	< 0.03
C^{+3}	0.06 ± 0.03	$\text{CCl}^{35}\text{Cl}^{37}$	0.30 ± 0.03
C^{+4}	< 0.02	CCl_2^{35}	0.81 ± 0.08
$(\text{Cl}^{35})^{+1}$	1.07 ± 0.10	CCl^{35}	0.39 ± 0.4
$(\text{Cl}^{35})^{+2}$	0.70 ± 0.09	CCl^{37}	0.20 ± 0.02
$(\text{Cl}^{35})^{+3}$	0.58 ± 0.06		
$(\text{Cl}^{35})^{+4}$	0.40 ± 0.06		

TABLE II. Fragmentation pattern from β^- , γ decay in $\text{CCl}_3\text{Br}^{82}$.

m/e	Fragment	Relative abundance	Ion yield (%)
201	$\text{CCl}_3\text{Kr}^{82}$	< 0.1	< 0.7
119	CCl_3	1.0	64 ± 1.4
84	$\text{CCl}^{35}\text{Cl}^{37}$	0.086	5.5 ± 1.0
82	$\text{CCl}^{35}\text{Cl}^{35} + \text{Kr}^{82}$	0.113	7.3 ± 0.6
49	CCl^{37}	0.039	2.5 ± 0.2
47	CCl^{35}	0.150	9.7 ± 0.3
37	Cl^{37}	0.027	1.7 ± 0.4
35	Cl^{35}	0.095	6.2 ± 0.3
12	C	0.045	2.9 ± 0.3
100.5	$(\text{CCl}_3\text{Kr}^{82})^{+2}$	< 0.01	< 0.7
59.5	$(\text{CCl}_3)^{+2}$	< 0.01	< 0.7
41	$(\text{Kr}^{82})^{+2}$	< 0.01	< 0.7
6	C^{+2}	< 0.01	< 0.7
18.5	$(\text{Cl}^{37})^{+2}$	< 0.01	< 0.7
17.5	$(\text{Cl}^{35})^{+2}$	< 0.01	< 0.7
164	$\text{CCl}_2\text{Kr}^{82}$	< 0.01	< 0.7
129	CClKr^{82}	< 0.01	< 0.7
94	CKr^{82}	< 0.01	< 0.7

on the reproducibility of repeat determinations. The charge distributions of the atomic species from breakup of $\text{CCl}_3\text{Br}^{80\text{m}}$ are shown in histogram form

Fig. 2. Charge spectra of Br^{80} atoms from nuclear isomeric transition of 4.4-hr $\text{Br}^{80\text{m}}$.

Fig. 3. Charge spectra of C^{12} atoms from $\text{Br}^{80\text{m}}$ decay.

in Figs. 2, 3, and 4. The $\text{Br}^{80\text{m}}$ results have been corrected for contributions from decay of the longer-lived Br^{82} activity.

It is seen that spectra of multiply charged atomic fragments dominate the mass pattern from the isomeric transition of 4.4-hr $\text{Br}^{80\text{m}}$ in CCl_3Br . In contrast, only singly charged species are

Fig. 4. Charge spectra of Cl^{35} and Cl^{37} atoms resulting from isomeric transition of $\text{Br}^{80\text{m}}$.

derived from β , γ decay of ^{82}Br , of which the organic ion CCl_3^+ accounts for almost two thirds of the total intensity. Since $^{80\text{m}}\text{Br}$ undergoes internal conversion followed by Auger electron transitions, the resultant daughter may bear a high positive charge. Estimates of the charge spread which may result on the daughter atom from these processes give a distribution peaked at about +7.¹ If the radioactive $^{80\text{m}}\text{Br}$ is attached to a molecule, charge transfer will take place prior to rupture because the time required for electronic processes is less than the periods of molecular vibration. The charge distributions of C^{12} , Cl^{35} , and Cl^{37} measured in this experiment demonstrate that internal charge transfer occurs readily and may in some cases be quite extensive. The data further indicate that molecular rupture by isomeric transition of $^{80\text{m}}\text{Br}$ occurs by multi-center Coulombic repulsion of the redistributed charges resulting from ejections of internal conversion and Auger electrons.

In a negative beta transition, on the other hand, the increase in nuclear charge produces a daughter of single positive charge, but orbital ionization has a probability proportional to $1/Z_{\text{eff}}^2$, where Z_{eff} is the effective nuclear charge at the electron shell of interest.⁵ For example, in the beta decay of Kr^{85} , Rb^{85} daughters have been observed to possess a charge distribution decreasing in intensity from +1 to +10, with 10.9% of the daughters bearing two charges.⁶ For He^6 decay, about 10% of the Li^6 are found to have a charge of +2.⁷ But when the beta emitter is incorporated into a molecule, intensities of multiply charged fragments formed in the beta

⁵ A. Migdal, J. Phys. U.S.S.R. 4, 449 (1941); J. S. Levinger, Phys. Rev. 90, 11 (1953); H. M. Schwartz, J. Chem. Phys. 21, 45 (1953).

⁶ A. H. Snell and Frances Pleasonton, Phys. Rev. 107, 740 (1957).

⁷ C. H. Johnson, F. Pleasonton, and A. H. Snell, Annual Progress Report, Physics Division, Oak Ridge National Laboratory, ORNL-2718, p. 5, June 1959.

decay have been observed to be very small.^{8,9} The results reported here (Table II) are in agreement with these published observations. No doubly charged species could be detected. Possibly, molecular ions with charge greater than one break apart by Coulomb repulsion in the source volume of the spectrometer and thus escape detection. In agreement with previous studies on beta emitters in molecules, the dominant species is the initial fragment (here, CCl_3^+). Apparently, the daughter ion from the beta transformation $(\text{CCl}_3\text{Kr}^{82})^+$ invariably breaks up, with the charge remaining with the organic fragment. Because the mass of $(\text{Kr}^{82})^+$ falls on that of the fragment $(\text{CCl}_2^{35})^+$, the resolution of the instrument does not permit distinguishing the two. But even if all of the intensity of the peak at mass 82 is ascribed to Kr^{82} (which is highly unlikely), at most 7.3% (Table II) of the breakups of $\text{CCl}_3\text{Kr}^{82}$ result in the charge going with the krypton; in the remaining decays the positive charge is taken by the organic fragment. The finding is consistent with the higher first ionization potential of Kr relative to that of CCl_3 .¹⁰ The CCl_3^+ may dissociate further in about one third of the decays as shown by the presence of ions with fewer chlorines and of Cl^+ in the mass pattern. Even quantitatively the results agree with those obtained in the tritium studies and show that in a high fraction of the beta transitions little excitation energy accrues to the daughter ion.

⁸ A. H. Snell and Frances Pleasonton, J. Phys. Chem. 62, 1377 (1958).

⁹ T. H. Carlson, J. Chem. Phys. 32, 1234 (1960).

¹⁰ F. H. Field and J. L. Franklin, Electron Impact Phenomena (Academic Press Inc., New York, 1957), pp. 123, 245, and 289.

V. THEORETICAL PHYSICS, GENERAL

V-3-7

Dynamics of Nuclear Collective Motion

(51210-01)

D. R. Inglis and Kiuck Lee

Reported by D. R. Inglis

In the deformed oscillator model of nuclei, the model potential V_i represents the average interaction of the i th nucleon with all others and the total energy is approximated by the Hamiltonian $\sum_i (T_i + \frac{1}{2} V_i)$, with a factor $\frac{1}{2}$ to avoid counting pairwise interactions twice. This has nondiagonal terms, because it is $T_i + V_i$ that is diagonal in the oscillator representation, and these terms have not been taken into account in treatments such as Nilsson's.¹ As was mentioned in more detail at the end of the previous report,² the contributions of these nondiagonal terms are small and do not appreciably affect the calculated equilibrium deformations.

One has less reason to expect V_i to resemble the sum of the pairwise interactions with other nucleons, $\sum_j v_{ij}$, in respect to nondiagonal elements than in respect to diagonal elements. The extent to which the nondiagonal elements of V_i are representative has been investigated by comparing them with the nondiagonal elements of phenomenological pairwise interactions, and it is found, not surprisingly, that the correspondence is only one of order of magnitude and not at all close in detail. The small practical effect of the nondiagonal terms in the V_i approximation arises from their order of magnitude and from cancellations among many terms, and the same reasons apply to lead one to expect a small contribution in the v_{ij} approximation although it is not practicable to calculate the cancellations in detail.

Work on this project is now complete. A paper entitled "Potential

¹ S. G. Nilsson, Kgl. Danske Videnskab. Selskab, Mat.-fys. Medd. 29, No. 16 (1955).

² D. R. Inglis and Kiuck Lee, Physics Division Summary Report ANL-6072 (Oct.-Nov. 1959), pp. 31-35.

V-8-4 Relationships of Collective Effects and the Shell Model
(51210-01)

Dieter Kurath

LEVEL ORDER IN THE $K = 0$ BANDS OF ODD-ODD DEFORMED NUCLEI

In an earlier report on this subject,¹ the effect of short-range interactions in odd-odd nuclei was investigated. It was assumed incorrectly that Talmi's coupling rule applies in this case, but the rule is true only for identical nucleons, so the conclusions are in error.

To obtain a correct estimate, a residual interaction is evaluated for the two intrinsic states which lead respectively to states of either odd or even angular momentum.

The interaction is

$$V = V_0 [(1 - a) + aP_\sigma] \delta(r_1 - r_2) \quad ,$$

where $\mathbf{P}_\sigma$ denotes the operator exchanging the spins of particles 1 and 2,

¹ Physics Division Summary Report ANL-61 30 (March 1960), pp. 43-47.

V_0 is a constant amplitude, and $\underline{a}$ indicates the amount of spin-exchange interaction. By expanding the Nilsson functions of the intrinsic states¹ into eigenfunctions of orbital angular momentum, it can be shown that the term $(1 - a)V_0 \delta(\underline{r}_1 - \underline{r}_2)$ has the same value whether we consider the intrinsic state for even angular momenta or that for odd angular momenta. The term which leads to a difference is

$$\begin{aligned} & \pm \left(\frac{a}{4\pi} \right) \sum_{\ell_n, \ell_n', \ell_p, \ell_p'} (-1)^{\ell_n + \ell_p + 1} \gamma(\ell_n \ell_p \ell_n' \ell_p') \sum_f (2f+1) (\ell_n f 0 0 | \ell_n' 0) \\ & \times (\ell_p f 0 0 | \ell_p' 0) \sum_{\Lambda_n, \Lambda_p} (-1)^{\Lambda_n - \Lambda_p} A_{\Lambda_n}^{\ell_n} A_{\Lambda_p}^{\ell_p} A_{\Lambda_n}^{\ell_n'} A_{\Lambda_p}^{\ell_p'} \\ & \times (\ell_n' f \Lambda_p \Lambda_n - \Lambda_p | \ell_n \Lambda_n) (\ell_p' f \Lambda_n \Lambda_p - \Lambda_n | \ell_p \Lambda_p), \end{aligned} \quad (1)$$

where γ is an integral over the radial wave functions, namely,

$$\gamma(\ell_n \ell_p \ell_n' \ell_p') = V_0 \int_0^\infty R_{\ell_n} R_{\ell_n'} R_{\ell_p} R_{\ell_p'} r^2 dr.$$

The A_{Λ}^{ℓ} are coefficients from the expansions of the Nilsson functions and the remaining symbols are Clebsch-Gordan coefficients. The sign in front of the whole expression is determined by whether we consider the intrinsic state for even angular momenta (+ sign) or odd angular momenta (- sign).

In general the evaluation of (1) will depend on the Nilsson coefficients pertinent to the specific states, but there is one limiting case in

which the result becomes rather simple. This occurs when there is a single pair of indices (l, Λ) dominant in either the neutron or the proton function. Then we see that only $\Lambda_n = -\Lambda_p$ gives a contribution. If in addition this Λ value is the dominant term in both functions, although the dominant l values are not necessarily alike, then the answer is clear cut. The expression (1) then becomes

$$\pm \left(\frac{a}{4\pi}\right) (-1)^{l_n + l_p + 1} \gamma(l_n l_p l_n l_p) \left[A_{\Lambda}^{l_n}\right]^2 \left[A_{\Lambda}^{l_p}\right]^2 \\ \times \sum_f (2f+1) (l_n f 00 | l_n 0) (l_p f 00 | l_p 0) (l_n f -\Lambda 2 \Lambda | l_n \Lambda) (l_n f \Lambda - 2 \Lambda | l_p - \Lambda), \quad (1')$$

where we have set $\Lambda_n = -\Lambda_p = \Lambda$.

The sign of the summation can be determined by using the symmetry relations of Regge² which lead to

$$(l f \Lambda - 2 \Lambda | l - \Lambda) = \left(\frac{2l+1}{2l+2\Lambda+1} \right)^{\frac{1}{2}} (l - \Lambda f 00 | l + \Lambda 0) .$$

Then since the sign of $(l_1 l_2 00 | l_3 0)$ is given by $(-1)^{\frac{1}{2}(l_3 - l_1 - l_2)}$, one sees that the sum over f in Eq. (1') is a positive quantity. Since $(a/4\pi)$ is positive and the integral $\gamma(l_n^2 l_p^2)$ is negative, the lower energy is obtained when we have

$$\pm (-1)^{l_n + l_p + 1} > 0 .$$

² T. Regge, Nuovo cimento 10, 544 (1958).

Here it should be remembered that the + sign goes with even angular momenta for the intrinsic state and the - sign goes with odd angular momenta. Since $l_n + l_p$ determines the parity of the intrinsic state, we can then say that:

Odd parity favors even angular momenta.

Even parity favors odd angular momenta.

It should be emphasized that this conclusion is valid only in the case in which the Nilsson functions for the neutron and the proton are each dominated by a single value l_x of orbital angular momentum and that in addition they both have the same dominant value Λ for the projection of orbital angular momentum on the axis of symmetry of the nucleus. In other cases more careful evaluation of (1) is necessary.

A case which fits the requirements for the simple estimate is Ho^{168} . Here the pertinent values are $l_n = 6$, $l_p = 5$, and $\Lambda = 3$ so that one expects the lowest state of the $K = 0$ band to be 0^- . There is experimental evidence that the states of odd angular momentum from the $K = 0$ band are raised with respect to those of even angular momentum in this nucleus.

PUBLICATIONS SINCE THE LAST REPORT

PAPERS

THERMODYNAMIC PROPERTIES OF THE WATER-BORIC OXIDE AND WATER-LITHIUM OXIDE SYSTEMS BY MASS SPECTROMETRIC METHODS

W. A. Chupka, J. Berkowitz, and D. J. Meschi.....(Project II-29)
 Proceedings of the Propellant Thermodynamics and Handling
 Conference, 1959, Special Report 12, Engineering Experiment
 Station, Ohio State University, pp. 19-22.

BOOK REVIEW: "THE THEORY OF ELEMENTARY PARTICLES" by James
 Hamilton

William C. Davidon
 Am. J. Phys. 28, 410 (April 1960).

HEAVY-ISOTOPE ABUNDANCES IN MIKE THERMONUCLEAR DEVICE

H. Diamond, P. R. Fields, C. S. Stevens, M. H. Studier, S. M. Fried,
 M. G. Inghram, D. C. Hess, G. L. Pyle, J. F. Mech, and W. M. Manning,
 Argonne National Laboratory, Argonne, Illinois; and A. Ghiorso, S. G.
 Thompson, G. H. Higgins, and G. T. Seaborg, Radiation Laboratory and
 Department of Chemistry, University of California, Berkeley, California;
 and C. I. Browne, H. L. Smith, and R. W. Spence, Los Alamos Scientific
 Laboratory, Los Alamos, New Mexico.
 Phys. Rev. 119, 2000-2004 (September 15, 1960).

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Malcolm H. Macfarlane and J. B. French (U. of Rochester)(Project V-9)
 Revs. Modern Phys. 32, 567-691 (July 1960).

CROSS SECTION FOR FORMATION OF DOUBLY-IONIZED HELIUM BY ELECTRON IMPACT

H. E. Stanton and J. E. Monahan.....(Project II-36)
 Phys. Rev. 119, 711-715 (July 15, 1960).

BARYON MASS SPECTRUM

Katsumi Tanaka.....(Project V-45)
 Phys. Rev. 119, 1436-1441 (August 15, 1960).

ADDITIONAL PAPERS ACCEPTED FOR PUBLICATION

MEASUREMENTS OF SPATIAL ASYMMETRIES IN THE DECAY OF POLARIZED NEUTRONS

M. T. Burgy, V. E. Krohn, T. B. Novey, and G. R. Ringo, and V. L. Telegdi.....(Project I-123)
Phys. Rev. in the December 1, 1960 issue.

PARAMETERS AND GAMMA-RAY SPECTRA OF NEUTRON RESONANCES IN THE ISOTOPES OF MERCURY

R. T. Carpenter and L. M. Bollinger.....(Projects I-3,7)
Nuclear Physics.

A GEOMETRIC THEORY OF CHARGE

H. Ekstein.....(Project V-42)
Phys. Rev. in the December 1, 1960 issue.

ACHIEVEMENT OF EXTREMELY HOMOGENEOUS MAGNETIC FIELDS

L. S. Goodman.....(Project I-80)
Rev. Sci. Instr.

THE CORRECTION OF RESONANCE PEAKS FOR EXPERIMENTAL RESOLUTION

R. O. Lane, N. F. Morehouse, Jr., and D. L. Phillips..(Project I-18)
Nuclear Instr. and Methods in December 1960 issue.

NUCLEAR DEFORMATION IN THE SPHEROIDAL SHELL MODEL

Kiuck Lee and D. R. Inglis.....(Project V-3)
Phys. Rev. in the December 1, 1960 issue.

ANALYSIS OF THE STRUCTURE OF NUCLEI FROM (d,t) REACTIONS

B. J. Raz, B. Zeidman, and J. L. Yntema.....(Project I-22)
Phys. Rev. in the December 1, 1960 issue..

REPULSION OF ENERGY LEVELS IN COMPLEX ATOMIC SPECTRA

Norbert Rosenzweig and Charles E. Porter (U. of Minnesota)(Project V-15)
Phys. Rev. in the December 1, 1960 issue.

(d,t) REACTIONS ON NUCLEI WITH $A \approx 60$

B. Zeidman, J. L. Yntema, and B. J. Raz.....(Project I-22)
Phys. Rev. in the December 1, 1960 issue.

PERSONNEL CHANGES IN THE ANL PHYSICS DIVISION

NEW MEMBERS IN THE DIVISION

Resident Research Associates

Mr. John Eric Lynn, United Kingdom Atomic Energy Authority, Harwell.

Neutron physics with the Argonne fast chopper. Came to Argonne on September 29, 1960. (Host: L. M. Bollinger.)

Dr. Dino Zei, Ripon College, Ripon, Wisconsin. Supervision of students at Argonne on half-year appointments from the Associated Colleges of the Midwest; experimental studies of the decay schemes of short-lived radioactive nuclides. Came to Argonne on September 9, 1960. (Host: S. B. Burson.)

Affiliates of the

International Institute of Nuclear Sciences and Engineering

Dr. Mirza-Agha Farvar, Iranian Atomic Energy Commission, Teheran, Iran.

Experimental studies of the decay schemes of short-lived radioactive nuclides. Came to Argonne on October 5, 1960.

(Host: S. B. Burson.)

Dr. Relja Popič, Boris Kidric Institute of Nuclear Sciences, Belgrade, Yugoslavia. Experimental studies with charged particles. Came to Argonne on October 5, 1960. (Host: S. S. Hanna.)

Student Aides (Associated Colleges of the Midwest)

Mr. James E. Geuths, Ripon College. Working with S. B. Burson on decay schemes of short-lived radioactive nuclides. Came to ANL on September 9, 1960.

Mr. Jerome B. Heath, Monmouth College. Working with D. C. Hess on mass spectrometric measurements of the purity of rare earths and of lead-lead ages of meteorites. Came to ANL on September 12, 1960.

Mr. G. Thomas Tisue, Beloit College. Working with L. J. Basile on energy transfer in liquid and plastic scintillators. Returned to ANL on September 12, 1960.

DEPARTURES

Dr. Dietrich H. Vincent joined the Physics Division as a resident research associate on September 22, 1958. He has collaborated with Luise Meyer-Schützmeister and L. L. Lee on a study of (p, γ) reactions (Project I-21) and with S. S. Hanna, L. Meyer-Schützmeister, and R. S. Preston on studies employing the Mössbauer effect (Project I-19). He terminated at ANL on September 9, 1960 to go to the Department of Nuclear Engineering, University of Michigan, Ann Arbor, Michigan where he plans to do cold-neutron spectroscopy.

Dr. Peter Rice-Evans joined the Physics Division as a resident research associate on January 21, 1959. He has collaborated with T. B. Novey, G. R. Ringo and others on experiments with polarized neutrons at CP-5 (Project I-123) and on the helicity of the neutrino emitted in the electron-capture decay of Be^7 (Project I-129). He terminated at ANL on September 23, 1960 to go to Columbia University where he will study scientific administration in the School of Business.