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β-γ (CP)-Asymmetry Coefficients in Isospin Forbidden Allowed Mixed β-Transitions

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Abstract

During the past years a large amount of β-γ (CP)-asymmetry coefficients have been measured for isospin forbidden allowed mixed β-transitions. In the following a compilation of all experimental results, their average for the different nuclei, the calculated Fermi matrix elements, isospin impurity coefficients and effective Coulomb matrix elements is given. It will be discussed, where the experimental accuracy should be improved.

Während der letzten Jahre wurde eine große Zahl von Asymmetriekoeffizienten der β-γ-Zirkularpolarisationskorrelation an gemischten β-Übergängen, bei denen das Fermi-Matrixelement isospinverboten ist, gemessen. Im folgenden werden alle experimentellen Resultate zusammengestellt und für die verschiedenen Kerne gemittelt. Aus diesen Mittelwerten werden die Fermi-Matrix-Elemente, Isospin-Unreinheitskoeffizienten und effektiven Coulomb-Matrixelemente berechnet. Es wird kurz diskutiert, wo die experimentelle Genauigkeit noch gesteigert werden sollte.

During the past years a large amount of β-γ (CP)-asymmetry coefficients have been measured for isospin forbidden allowed mixed β-transitions in order to determine fermi matrix elements, isospin impurity coefficients and effective Coulomb matrix elements. Up to 1967 these results have been listed more or less completely several times by different authors [1-4]. A great number of new measurements have been carried out since with much smaller errors than in previous investigations. In the following table 1 a new compilation of all experimental results and their averages are given. In some cases it is possible to determine the Fermi matrix elements also by measurements on oriented nuclei. Therefore the following notation is used to indicate this: The letter C means β-γ (CP) correlation and O oriented nuclei. The data obtained with oriented nuclei are listed as if measured with β-γ (CP) correlation. Since, especially for the older measurements, there are discrepencies between different experimental results, which lie far outside the quoted errors, all the results could not be adopted for the weighted mean of the individual values. The number CNO indicates, if the value is adopted or not: O is adopted and 1 not adopted. The weights are the reciprocals of the squares of the errors σ_i. The error σ of the mean is than given by

$$\sigma = \sqrt{\frac{1}{\sum_i \frac{1}{\sigma_i^2}}}$$

The other notations in table 1 are self-evident. From the average asymmetry coefficients listed the Fermi matrix elements $|M_F|$, the isospin impurity coefficients $|\alpha|$ and the effective Coulomb-matrix elements $|V_C|$ have been calculated and compiled in table 2. The notation in table 2 is:

MF $\hat{=}$ $|M_F|$; AP $\hat{=}$ $|\alpha|$; V(KEV) $\hat{=}$ $|V_C|$ in keV

With exception of Ni^{65}, where a mixing ratio $\delta(E2/M1)=-0.43$ has been taken, the γ-transitions have been assumed as pure transitions with the lowest possible multipole order. The methods used for this calculation have been extensively described, for example, in ref. [3,5]. The Coulomb energy differences between parent and analogue states, which are necessary for the calculation of the effective Coulomb matrix elements, have been calculated with the help of a formula given in ref. [6]. The log ft-values and the maximum β-energies also needed for the calculations have been taken from standard compilations of decay schemes, for ft (O^{14}) the value 3116 sec has been used.

In table 3 these and other relevant data are listed. The notation in this table is:

TRANSITION: -1 means β^--transition
and +1 β^+-transition

SPIN $\hat{=}$ Spin of the nuclear levels involved in the β-transition for example 2.0 means 2 and 2.5 5/2

ISOSPIN $\hat{=}$ Isospin of the parent nucleus for example 1.0 means 1 and 1.5 3/2

EO $\hat{=}$ Maximum kinetic energy of the β-transition in MeV

LOGFT $\hat{=}$ logft-value of the β-transition

DE $\hat{=}$ for β^--transitions energy separation ΔE in the daughter nucleus between the final state of the β-transition and the analogue state in MeV

for β^+-transitions energy separation ΔE in the parent nucleus between the initial state of the β-transition and the analogue state in MeV (see ref. [5])

Taking table 2 one can establish that especially in the cases of F^{20}, Al^{24}, Mg^{27}, Ca^{49} and Fe^{59} 2 the experimental accuracy should be improved. From table 1 one must conclude, that there are only four cases, where greater differences between different recent measurements exist: Sc^{46}, V^{48}, Co^{58} and Sb^{124}. In Fe^{59} 2 the situation is much clearer after the measurement of Tirsell and Mann 1967, who used the transmission method, while the other groups used the forward scattering method, which is not suitable in this case.

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TABLE I

NUCLEUS	ASYM.COEFF.	ERROR	METHOD	CNO	AUTHOR AND YEAR		NO
F 20	0.15000	0.0700	C	0	FREIBERG AND SOERGEL	1961	1)
	0.14000	0.0700	C	0	LOBASHOV AND NAZARENKO	1962	2)
	0.17400	0.0140	C	0	MANN AND BLOOM	1965	3)
	0.17185	0.0135					
NA 24	-0.06800	0.0470	C	1	APPEL AND SCHOPPER	1957	1)
	0.07000	0.0400	C	0	BOEHM AND WAPSTRA	1957	2)
	0.12000	0.0300	C	0	MAYER-KUCKUK AND NIERHAUS	1959	3)
	0.06000	0.0300	C	0	STEFFEN	1959	4)
	0.08500	0.0270	C	0	BLOOM ET AL.	1960/62	5)
	0.10400	0.0260	C	0	HAASE ET AL.	1963	6)
	0.09100	0.0170	C	0	BLOOM ET AL.	1964	7)
	0.09300	0.0090	C	0	SCHOPPER ET AL.	1965	8)
	0.10200	0.0060	C	0	BEHRENS	1967	9)
	0.09761	0.0045					
AL 24	-0.08900	0.0570	C	0	HAASE ET AL.	1963	1)
	-0.08400	0.0540	C	0	BLOOM ET AL.	1964	2)
	-0.08636	0.0392					
MG 27	-0.22100	0.0190	C	0	BIGONI ET AL.	1969	1)
	-0.22100	0.0190					
A 41	0.33000	0.0700	C	1	MAYER-KUCKUK ET AL.	1960	1)
	0.06100	0.0700	C	0	BLOOM ET AL.	1960/62	2)
	0.09000	0.0400	C	0	CHABRE AND DEPOMMIER	1962/63	3)
	0.06600	0.0250	C	0	BEHRENS	1967	4)
	0.07500	0.0075	C	0	BEHRENS AND KOENIG	1967	5)
	0.07461	0.0070					
SC 44	-0.02000	0.0400	C	1	BOEHM AND WAPSTRA	1957	1)
	-0.15100	0.0300	C	0	BLOOM ET AL.	1960/62	2)
	-0.12700	0.0140	C	0	MANN ET AL.	1965	3)
	-0.13129	0.0127					
SC 46	0.33000	0.0400	C	1	BOEHM AND WAPSTRA	1957	1)
	0.29000	0.1100	C	1	LUNDBY ET AL.	1958	2)
	0.24000	0.0400	C	1	JUENGST AND SCHOPPER	1958	3)

NUCLEUS	ASYM.COEFF.	ERROR	METHOD	CNO	AUTHOR AND YEAR		NO
	0.24000	0.0200	C	1	STEFFEN	1959/60	4)
	0.07500	0.0180	C	0	BLOOM ET AL.	1960/62	5)
	0.10000	0.0200	C	0	DANIEL AND KUNTZE	1961	6)
	0.21500	0.0190	C	1	BOEHM AND ROGERS	1962	7)
	0.11000	0.0200	C	0	BERTHIER	1962	8)
	0.07900	0.0130	C	0	HAASE	1962	9)
	0.19000	0.0300	C	1	SINGRU AND STEFFEN	1963	10)
	0.11300	0.0080	C	0	DANIEL ET AL.	1963	11)
	0.09700	0.0120	C	0	MISKEL ET AL.	1963	12)
	0.11000	0.0100	C	0	CHABRE	1963	13)
	0.07700	0.0100	C	0	WEI ET AL.	1964	14)
	0.09200	0.0070	C	0	MANN ET AL.	1965	15)
	0.13000	0.0200	C	0	MITRA AND PADHI	1966	16)
	0.10300	0.0040	C	0	BEHRENS	1967	17)
	0.06000	0.0300	C	0	MEULENBERG ET AL.	1967	18)
	0.08430	0.0030	C	0	PINGOT	1969	19)
	0.09286	0.0020					
SC 48	0.06000	0.0400	C	0	VAN NOOIJEN	1958	1)
	0.06300	0.0130	C	0	MANN ET AL.	1965	2)
	0.11000	0.0600	C	0	VAN NOOIJEN ET AL.	1965	3)
	0.05800	0.0030	C	0	MANN ET AL.	1968	4)
	0.05530	0.0055	C	0	BEHRENS AND WISCHHUSEN	1969	5)
	0.05771	0.0026					
V 48	0.06000	0.0500	C	1	BOEHM AND WAPSTRA	1957	1)
	0.0	0.0400	C	0	DANIEL AND KUNTZE	1961	2)
	-0.06600	0.0350	C	0	MANN ET AL.	1962	3)
	-0.03600	0.0050	C	0	BLOOM AND MANN	1966	4)
	-0.05900	0.0100	C	0	BEHRENS	1967	5)
	-0.00200	0.0240	C	0	VAN NOOIJEN ET AL.	1968	6)
	-0.03925	0.0043					
CA 49	-0.13200	0.0170	C	0	MANN AND BLOOM	1970	1)
	-0.13200	0.0170					
MN 52	-0.03300	0.0040	O	0	POSTMA ET AL.	1957	1)
	-0.16000	0.0500	C	1	BOEHM	1958	2)
	-0.02100	0.0040	O	0	AMBLER ET AL.	1958	3)
	-0.10000	0.0300	C	1	BOEHM	1962	4)
	-0.09100	0.0280	C	1	BLOOM ET AL.	1962	5)
	0.0	0.0200	C	0	DANIEL ET AL.	1962	6)
	-0.06000	0.0080	C	1	MANN ET AL.	1965	7)
	-0.01900	0.0100	C	0	BEHRENS	1967	8)
	-0.02700	0.0090	C	0	SAWYER	1968	9)
	-0.02600	0.0040	C	0	SAWYER	1968	10)
	-0.02601	0.0022					
MN 52M	-0.14100	0.0160	C	0	BLOOM AND MANN	1966	1)

NUCLEUS	ASYM.COEFF.	ERROR	METHOD	CNO	AUTHOR AND YEAR		NO
	-0.14100	0.0160					
CO 56	-0.07400	0.0090	O	1	AMBLER ET AL.	1957	1)
	-0.01000	0.0500	C	0	DANIEL ET AL.	1961/64	2)
	0.0	0.0300	C	0	MANN ET AL.	1962	3)
	0.01400	0.0220	C	0	BHATTACHERJEE ET AL.	1967	4)
	0.00200	0.0100	C	0	BEHRENS	1967	5)
	0.00331	0.0086					
NI 57	0.07100	0.0110	C	0	ATKINSON ET AL.	1968	1)
	0.07100	0.0110					
CO 58	0.11000	0.0500	O	1	GRIFFING AND WHEATLEY	1956	1)
	-0.17300	0.0440	O	0	POSTMA ET AL.	1957	2)
	-0.17100	0.0240	O	0	AMBLER ET AL.	1957	3)
	-0.14000	0.0700	C	0	BOEHM AND WAPSTRA	1957	4)
	-0.09300	0.0250	O	1	DAGLEY ET AL.	1958	5)
	-0.10300	0.0320	C	1	COLLIN ET AL.	1965	6)
	-0.18500	0.0110	C	0	MANN ET AL.	1965	7)
	-0.10600	0.0230	C	1	BEHRENS	1967	8)
	-0.16000	0.0400	C	0	BHATTACHERJEE ET AL.	1967	9)
	-0.18000	0.0400	C	0	MEULENBERG ET AL.	1968	10)
	-0.18012	0.0091					
1 FE 59	-0.46000	0.0800	C	1	FORSTER AND SANDERS	1957	1)
	-0.06600	0.0370	C	1	HAASE	1962	2)
	-0.13000	0.0400	C	0	COLLIN ET AL.	1964	3)
	-0.20500	0.0190	C	0	MANN ET AL.	1962/64	4)
	-0.25000	0.0700	C	0	KNEISSL AND SCHNEIDER	1965	5)
	-0.15800	0.0070	C	0	BEHRENS AND ZERNIAL	1970	6)
	-0.16348	0.0065					
2 FE 59	-0.04000	0.1100	C	0	FORSTER AND SANDERS	1960	1)
	-0.40000	0.2000	C	0	HAASE	1962	2)
	-0.17000	0.1000	C	0	COLLIN ET AL.	1964	3)
	-0.04200	0.0430	C	1	MANN ET AL.	1962/64	4)
	-0.02000	0.1500	C	0	KNEISSL AND SCHNEIDER	1965	5)
	-0.15400	0.0230	C	0	TIRSELL AND MANN	1967	7)
	-0.15044	0.0216					
NI 65	0.23000	0.0400	C	0	ATKINSON ET AL.	1968	1)
	0.29200	0.0370	C	0	BEHRENS AND WISCHHUSEN	1969	2)

NUCLEUS	ASYM.COEFF.	ERROR	METHOD	CNO	AUTHOR AND YEAR		NO
	0.26341	0.0272					
AG 110M	0.07000	0.0200	C	0	DANIEL ET AL.	1963	1)
	0.05800	0.0070	C	0	BEHRENS	1967	2)
	0.05490	0.0013	C	0	PINGOT	1970	3)
	0.05506	0.0013					
SB 124	0.22600	0.0160	C	1	MANN ET AL.	1965	1)
	0.35600	0.0300	C	0	TIRSELL AND TALBERT	1965	2)
	0.28000	0.0100	C	0	MANN ET AL.	1965	3)
	0.30000	0.0300	C	0	BHATTACHERJEE ET AL.	1965	4)
	0.27800	0.0130	C	0	BEHRENS AND ZERNIAL	1970	5)
	0.17200	0.0040	C	1	PINGOT	1970	6)
	0.28523	0.0074					
CS 134	-0.07400	0.0220	C	0	MANN ET AL.	1962	1)
	-0.13000	0.0200	C	1	DANIEL ET AL.	1963	2)
	-0.07700	0.0130	C	0	TIRSELL AND TALBERT	1965	3)
	-0.07200	0.0180	C	0	BHATTACHERJEE ET AL.	1967	4)
	-0.06900	0.0070	C	0	BEHRENS	1967	5)
	-0.07020	0.0024	C	0	PINGOT	1970	6)
	-0.07034	0.0022					
EU 152	0.10800	0.0320	C	0	BERTHIER ET AL.	1960	1)
	0.14000	0.0400	C	0	COLLIN ET AL.	1964	2)
	0.15000	0.0200	C	0	BHATTACHERJEE ET AL.	1965	3)
	0.10700	0.0120	C	0	BEHRENS AND WISCHHUSEN	1969	4)
	0.11869	0.0095					

TABLE II

NUCLEUS	Y	ERROR	MF(*1000)	ERROR	AP(*1000)	ERROR	V(KEV)	ERROR
F 20	-0.00636	0.0165	1.587	4.130	1.122	2.920	9.725	25.304
NA 24	-0.01921	0.0061	1.305	0.413	0.923	0.292	4.898	1.548
AL 24	0.00407	0.0528	0.203	2.622	0.143	1.854	0.747	9.662
MG 27	0.00317	0.0494	1.118	17.371	0.645	10.029	3.843	59.733
A 41	0.02722	0.0093	6.789	2.307	3.036	1.032	21.659	7.361
SC 44	-0.04303	0.0154	7.590	2.699	3.795	1.349	15.309	5.443
SC 46	-0.01281	0.0027	0.803	0.167	0.402	0.084	2.873	0.598
SC 48	-0.00299	0.0036	0.374	0.447	0.153	0.183	1.128	1.349
V 48	-0.05896	0.0058	4.134	0.404	2.067	0.202	11.051	1.080
CA 49	0.00258	0.0329	0.723	9.210	0.241	3.070	2.014	25.665
MN 52	-0.04097	0.0030	5.742	0.421	2.871	0.210	17.208	1.260
MN 52M	-0.03127	0.0194	4.920	3.048	2.460	1.524	9.690	6.002
CO 56	-0.11629	0.0117	0.405	0.040	0.202	0.020	1.137	0.111
NI 57	-0.11877	0.0209	14.653	2.509	8.460	1.449	55.204	9.452
CO 58	0.01654	0.0113	0.654	0.446	0.267	0.182	1.742	1.188
1 FE 59	-0.05949	0.0130	2.090	0.455	0.790	0.172	6.690	1.455
2 FE 59	-0.03345	0.0428	2.892	3.686	1.093	1.393	9.041	11.523
NI 65	-0.00305	0.0178	0.191	1.114	0.064	0.371	0.602	3.508
AG 110M	0.00068	0.0018	0.004	0.011	0.001	0.003	0.014	0.036
SB 124	-0.10542	0.0069	1.036	0.066	0.221	0.014	3.029	0.193
CS 134	0.21035	0.0032	0.633	0.009	0.129	0.002	1.871	0.026
EU 152	0.04137	0.0082	0.016	0.003	0.003	0.001	0.051	0.010

TABLE III

NUCLEUS	TRANSITION	SPIN	ISOSPIN	EO	LOGFT	DE
F 20	-1	2.0	1.0	5.420	5.00	8.67
NA 24	-1	4.0	1.0	1.391	6.13	5.31
AL 24	1	4.0	1.0	8.500	6.40	5.21
MG 27	-1	0.5	1.5	1.750	4.70	5.96
A 41	-1	3.5	2.5	1.198	5.00	7.13
SC 44	1	2.0	1.0	1.471	5.30	4.03
SC 46	-1	4.0	2.0	0.357	6.20	7.16
SC 48	-1	6.0	3.0	0.654	5.60	7.38
V 48	1	4.0	1.0	0.698	6.10	5.35
CA 49	-1	1.5	4.5	2.000	4.90	8.36
MN 52	1	6.0	1.0	0.575	5.50	5.99
MN 52M	1	2.0	1.0	2.630	5.40	3.94
CO 56	1	4.0	1.0	1.460	8.70	5.62
NI 57	1	1.5	0.5	0.840	5.60	6.53
CO 58	1	2.0	2.0	0.485	6.60	6.52
1 FE 59	-1	1.5	3.5	0.469	6.70	8.47
2 FE 59	-1	1.5	3.5	0.273	5.92	8.27
NI 65	-1	2.5	4.5	1.020	6.20	9.45
AG 110M	-1	6.0	8.0	0.529	8.20	12.98
SB 124	-1	3.0	11.0	0.622	7.80	13.71
CS 134	-1	4.0	12.0	0.662	8.80	14.48
EU 152	-1	3.0	13.0	0.690	10.60	15.97

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