n

$I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ Status: ∗∗∗∗

We have omitted some results that have been superseded by later experiments. See our earlier editions.

n MASS

The mass is known much more precisely in u (atomic mass units) than in MeV; see the footnotes. The conversion from u to MeV, 1 u = 931.49432±0.00028 MeV, involves the relatively poorly known electronic charge. The DIFILIPPO 94 value, in u, is by far the best, but when converted to MeV differs only negligibly from the 1986 CODATA value, which, for consistency, we stick with.

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
939.56563±0.00028	[1] COHEN	87	RVUE	1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
939.56565±0.00028	[2,3] DIFILIPPO	94	TRAP	Penning trap
939.56564±0.00028	[3,4] GREENE	86	SPEC	$np \rightarrow d\gamma$
939.5731 ±0.0027	[3] COHEN	73	RVUE	1973 CODATA value

[1] The mass is known much more precisely in u: $m = 1.008664904 \pm 0.000000014$ u.

[2] The mass is known much more precisely in u: $m = 1.0086649235 \pm 0.0000000023$ u. We use the conversion factor given above to get the mass in MeV.

[3] These determinations are not independent of the $m_n - m_p$ measurements below.

[4] The mass is known much more precisely in u: $m = 1.008664919 \pm 0.000000014$ u.

$\overline{n}$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
939.485±0.051	59	[5] CRESTI	86	HBC	$\overline{p}p \rightarrow \overline{n}n$

[5] This is a corrected result (see the erratum). The error is statistical. The maximum systematic error is 0.029 MeV.

$(m_n - m_{\overline{n}})\ /\ m_{\text{average}}$

A test of *CPT* invariance. Calculated from the *n* and $\overline{n}$ masses, above.

VALUE	*DOCUMENT ID*
(9±5) × 10^{-5} OUR EVALUATION	

$m_n - m_p$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1.293318 ±0.000009	[6] COHEN	87	RVUE	1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.2933328±0.0000072	GREENE	86	SPEC	$np \rightarrow d\gamma$
1.293429 ±0.000036	COHEN	73	RVUE	1973 CODATA value

[6] Calculated by us from the COHEN 87 ratio $m_n/m_p = 1.001378404 \pm 0.000000009$. In u, $m_n - m_p = 0.001388434 \pm 0.000000009$ u.

n MEAN LIFE

We now compile only direct measurements of the lifetime, not those inferred from decay correlation measurements. (Limits on lifetimes for *bound* neutrons are given in the section "*p* PARTIAL MEAN LIVES.")

For a review, see EROZOLIMSKII 89 and papers that follow it in an issue of NIM devoted to the "Proceedings of the International Workshop on Fundamental Physics with Slow Neutrons" (Grenoble 1989). For later reviews and/or commentary, see FREEDMAN 90, SCHRECKENBACH 92, and PENDLEBURY 93.

VALUE (s)	*DOCUMENT ID*	*TECN*	*COMMENT*
886.7± 1.9 OUR AVERAGE	Error includes scale factor of 1.2.		
889.2± 3.0± 3.8	BYRNE 96	CNTR	Penning trap
882.6± 2.7	[7] MAMPE 93	CNTR	Gravitational trap
888.4± 3.1± 1.1	NESVIZHEV... 92	CNTR	Gravitational trap
878 ±27 ±14	KOSSAKOW... 89	TPC	Pulsed beam
887.6± 3.0	MAMPE 89	CNTR	Gravitational trap
877 ±10	PAUL 89	CNTR	Storage ring
876 ±10 ±19	LAST 88	SPEC	Pulsed beam
891 ± 9	SPIVAK 88	CNTR	Beam
903 ±13	KOSVINTSEV 86	CNTR	Gravitational trap
918 ±14	CHRISTENSEN72	CNTR	
• • • We do not use the following data for averages, fits, limits, etc. • • •			
888.4± 2.9	ALFIMENKOV 90	CNTR	See NESVIZHEVSKII 92
893.6± 3.8± 3.7	BYRNE 90	CNTR	See BYRNE 96
937 ±18	[8] BYRNE 80	CNTR	
875 ±95	KOSVINTSEV 80	CNTR	
881 ± 8	BONDAREN... 78	CNTR	See SPIVAK 88

[7] IGNATOVICH 95 calls into question some of the corrections and averaging procedures used by MAMPE 93. The response, BONDARENKO 96, denies the validity of the criticisms.

[8] This measurement has been withdrawn (J. Byrne, private communication, 1990).

n MAGNETIC MOMENT

VALUE (μ_N)	*DOCUMENT ID*	*TECN*	*COMMENT*
−1.91304275±0.00000045	COHEN 87	RVUE	1986 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−1.91304277±0.00000048	[9] GREENE 82	MRS	

[9] GREENE 82 measures the moment to be $(1.04187564 \pm 0.00000026) \times 10^{-3}$ Bohr magnetons. The value above is obtained by multiplying this by $m_p/m_e = 1836.152701 \pm 0.000037$ (the 1986 CODATA value from COHEN 87).

n ELECTRIC DIPOLE MOMENT

A nonzero value is forbidden by both T invariance and P invariance. A number of early results have been omitted. See RAMSEY 90 and GOLUB 94 for reviews.

VALUE (10^{-25} e cm)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
< 0.97	90	ALTAREV 96	MRS	$(+0.26 \pm 0.40 \pm 0.16) \times 10^{-25}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 1.1	95	ALTAREV 92	MRS	See ALTAREV 96
< 1.2	95	SMITH 90	MRS	$d = (-0.3 \pm 0.5) \times 10^{-25}$
< 2.6	95	ALTAREV 86	MRS	$d = (-1.4 \pm 0.6) \times 10^{-25}$
0.3 ±4.8		PENDLEBURY 84	MRS	Ultracold neutrons
< 6	90	ALTAREV 81	MRS	$d = (2.1 \pm 2.4) \times 10^{-25}$
<16	90	ALTAREV 79	MRS	$d = (4.0 \pm 7.5) \times 10^{-25}$

n ELECTRIC POLARIZABILITY α_n

Following is the electric polarizability α_n defined in terms of the induced electric dipole moment by $\mathbf{D} = 4\pi\epsilon_0\alpha_n\mathbf{E}$. For a review, see SCHMIEDMAYER 89.

VALUE (10^{-3} fm^3)	*DOCUMENT ID*	*TECN*	*COMMENT*
$0.98^{+0.19}_{-0.23}$ OUR AVERAGE Error includes scale factor of 1.1.			
0.0 ±0.5	[10] KOESTER 95	CNTR	n Pb, n Bi transmission
1.20±0.15±0.20	SCHMIEDM... 91	CNTR	n Pb transmission
$1.07^{+0.33}_{-1.07}$	ROSE 90B	CNTR	$\gamma d \rightarrow \gamma n p$
0.8 ±1.0	KOESTER 88	CNTR	n Pb, n Bi transmission
1.2 ±1.0	SCHMIEDM... 88	CNTR	n Pb, n C transmission
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$1.17^{+0.43}_{-1.17}$	ROSE 90	CNTR	See ROSE 90B

[10] KOESTER 95 uses natural Pb and the isotopes 208, 207, and 206. See this paper for a discussion of methods used by various groups to extract α_n from data.

n CHARGE

See also "$|q_p + q_e|/e$" in the proton Listings.

VALUE (10^{-21} e)	*DOCUMENT ID*	*TECN*	*COMMENT*
− 0.4± 1.1	[11] BAUMANN 88		Cold n deflection
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−15 ±22	[12] GAEHLER 82	CNTR	Reactor neutrons

[11] The BAUMANN 88 error ±1.1 gives the 68% CL limits about the the value −0.4.

[12] The GAEHLER 82 error ±22 gives the 90% CL limits about the the value −15.

LIMIT ON $n\overline{n}$ OSCILLATIONS

Mean Time for $n\overline{n}$ Transition in Vacuum

A test of $\Delta B=2$ baryon number nonconservation. MOHAPATRA 80 and MOHAPATRA 89 discuss the theoretical motivations for looking for $n\overline{n}$ oscillations. DOVER 83 and DOVER 85 give phenomenological analyses. The best limits come from looking for the decay of neutrons bound in nuclei. However, these analyses require model-dependent corrections for nuclear effects. See KABIR 83, DOVER 89, and ALBERICO 91 for discussions. Direct searches for $n \rightarrow \overline{n}$ transitions using reactor neutrons are cleaner but give somewhat poorer limits. We include limits for both free and bound neutrons in the Summary Table.

VALUE (s)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{>1.2 \times 10^{8}}$	90	BERGER	90	FREJ	n bound in iron
$\mathbf{>1.2 \times 10^{8}}$	90	TAKITA	86	CNTR	Kamiokande
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$>8.6 \times 10^{7}$	90	BALDO-...	94	CNTR	Reactor neutrons
$>1 \times 10^{7}$	90	BALDO-...	90	CNTR	See BALDO-CEOLIN 94
$>4.9 \times 10^{5}$	90	BRESSI	90	CNTR	Reactor neutrons
$>4.7 \times 10^{5}$	90	BRESSI	89	CNTR	See BRESSI 90
$>1 \times 10^{6}$	90	FIDECARO	85	CNTR	Reactor neutrons
$>8.8 \times 10^{7}$	90	PARK	85B	CNTR	
$>3 \times 10^{7}$		BATTISTONI	84	NUSX	
$> 2.7 \times 10^{7}$–1.1×10^{8}		JONES	84	CNTR	
$>2 \times 10^{7}$		CHERRY	83	CNTR	

n DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Confidence level
Γ_1	$p e^{-} \overline{\nu}_e$		100 %	
Γ_2	hydrogen-atom$\overline{\nu}_e$			

Charge conservation (Q) violating mode

	Mode		Fraction (Γ_i/Γ)	Confidence level
Γ_3	$p \nu_e \overline{\nu}_e$	Q	$< 8 \times 10^{-27}$	68%

n BRANCHING RATIOS

$\Gamma(\text{hydrogen-atom}\overline{\nu}_e)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<3 \times 10^{-2}$	95	[13] GREEN	90	RVUE

[13] GREEN 90 infers that $\tau(\text{hydrogen-atom}\overline{\nu}_e) > 3 \times 10^{4}$ s by comparing neutron lifetime measurements made in storage experiments with those made in β-decay experiments. However, the result depends sensitively on the lifetime measurements, and does not of course take into account more recent measurements of same.

$\Gamma(p \nu_e \overline{\nu}_e)/\Gamma_{\text{total}}$ **Γ_3/Γ**

Forbidden by charge conservation.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<8 \times 10^{-27}$	68	[14] NORMAN	96	RVUE	^{71}Ga → ^{71}Ge neutrals
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<9.7 \times 10^{-18}$	90	ROY	83	CNTR	^{113}Cd → ^{113m}In neut.
$<7.9 \times 10^{-21}$		VAIDYA	83	CNTR	^{87}Rb → ^{87m}Sr neut.
$<9 \times 10^{-24}$	90	BARABANOV	80	CNTR	^{71}Ga → ^{71}GeX
$<3 \times 10^{-19}$		NORMAN	79	CNTR	^{87}Rb → ^{87m}Sr neut.

[14] NORMAN 96 gets this limit by attributing SAGE and GALLEX counting rates to the charge-nonconserving transition ^{71}Ga → ^{71}Ge+neutrals rather than to solar-neutrino reactions.

NOTE ON BARYON DECAY PARAMETERS

Written 1996 by E.D. Commins (University of California, Berkeley).

Baryon semileptonic decays

The typical spin-1/2 baryon semileptonic decay is described by a matrix element, the hadronic part of which may be written as:

$$\overline{B}_f \left[f_1(q^2)\gamma_\lambda + i\ f_2(q^2)\sigma_{\lambda\mu}q^\mu + g_1(q^2)\gamma_\lambda\gamma_5 + g_3(q^2)\gamma_5 q_\lambda \right] B_i \ .$$

Here B_i and $\overline{B}_f$ are spinors describing the initial and final baryons, and $q = p_i - p_f$, while the terms in f_1, f_2, g_1, and g_3 account for vector, induced tensor ("weak magnetism"), axial vector, and induced pseudoscalar contributions [1]. Second-class current contributions are ignored here. In the limit of zero momentum transfer, f_1 reduces to the vector coupling constant g_V, and g_1 reduces to the axial-vector coupling constant g_A. The latter coefficients are related by Cabibbo's theory [2], generalized to six quarks (and three mixing angles) by Kobayashi and Maskawa [3]. The g_3 term is negligible for transitions in which an $e^\pm$ is emitted, and gives a very small correction, which can be estimated by PCAC [4], for $\mu^\pm$ modes. Recoil effects include weak magnetism, and are taken into account adequately by considering terms of first order in

$$\delta = \frac{m_i - m_f}{m_i + m_f} \ ,$$

where m_i and m_f are the masses of the initial and final baryons.

The experimental quantities of interest are the total decay rate, the lepton-neutrino angular correlation, the asymmetry coefficients in the decay of a polarized initial baryon, and the polarization of the decay baryon in its own rest frame for an unpolarized initial baryon. Formulae for these quantities are derived by standard means [5] and are analogous to formulae for nuclear beta decay [6]. We use the notation of Ref. 6 in the Listings for neutron beta decay. For comparison with experiments at higher q^2, it is necessary to modify the form factors at $q^2 = 0$ by a "dipole" q^2 dependence, and for high-precision comparisons to apply appropriate radiative corrections [7].

The ratio g_A/g_V may be written as

$$g_A/g_V = \left| \, g_A/g_V \, \right| e^{i\phi_{AV}} \ .$$

The presence of a "triple correlation" term in the transition probability, proportional to $\mathrm{Im}(g_A/g_V)$ and of the form

$$\boldsymbol{\sigma}_i \cdot (\mathbf{p}_\ell \times \mathbf{p}_\nu)$$

for initial baryon polarization or

$$\boldsymbol{\sigma}_f \cdot (\mathbf{p}_\ell \times \mathbf{p}_\nu)$$

for final baryon polarization, would indicate failure of time-reversal invariance. The phase angle ϕ has been measured precisely only in neutron decay (and in ^{19}Ne nuclear beta decay), and the results are consistent with T invariance.

Hyperon nonleptonic decays

The amplitude for a spin-1/2 hyperon decaying into a spin-1/2 baryon and a spin-0 meson may be written in the form

$$M = G_F\, m_\pi^2 \cdot \overline{B}_f\, (A - B\gamma_5)\, B_i \ ,$$

where A and B are constants [1]. The transition rate is proportional to

$$\begin{aligned} R = 1 &+ \gamma\, \widehat{\boldsymbol{\omega}}_f \cdot \widehat{\boldsymbol{\omega}}_i + (1-\gamma)(\widehat{\boldsymbol{\omega}}_f \cdot \widehat{\mathbf{n}})(\widehat{\boldsymbol{\omega}}_i \cdot \widehat{\mathbf{n}}) \\ &+ \alpha(\widehat{\boldsymbol{\omega}}_f \cdot \widehat{\mathbf{n}} + \widehat{\boldsymbol{\omega}}_i \cdot \widehat{\mathbf{n}}) + \beta \widehat{\mathbf{n}} \cdot (\widehat{\boldsymbol{\omega}}_f \times \widehat{\boldsymbol{\omega}}_i) \ , \end{aligned}$$

where $\widehat{\mathbf{n}}$ is a unit vector in the direction of the final baryon momentum, and $\widehat{\boldsymbol{\omega}}_i$ and $\widehat{\boldsymbol{\omega}}_f$ are unit vectors in the directions of the initial and final baryon spins. (The sign of the last term in the above equation was incorrect in our 1988 and 1990 editions.) The parameters α, β, and γ are defined as

$$\begin{aligned} \alpha &= 2\,\mathrm{Re}(s^* p)/(\,|\,s\,|^2 + \,|\,p\,|^2) \ , \\ \beta &= 2\,\mathrm{Im}(s^* p)/(\,|\,s\,|^2 + \,|\,p\,|^2) \ , \\ \gamma &= (\,|\,s\,|^2 - \,|\,p\,|^2)/(\,|\,s\,|^2 + \,|\,p\,|^2) \ , \end{aligned}$$

where $s = A$ and $p = \,|\,\mathbf{p}_f\,|\,B/(E_f + m_f)$; here E_f and $\mathbf{p}_f$ are the energy and momentum of the final baryon. The parameters α, β, and γ satisfy

$$\alpha^2 + \beta^2 + \gamma^2 = 1 \ .$$

If the hyperon polarization is $\mathbf{P}_Y$, the polarization $\mathbf{P}_B$ of the decay baryons is

$$\mathbf{P}_B = \frac{(\alpha + \mathbf{P}_Y \cdot \widehat{\mathbf{n}})\widehat{\mathbf{n}} + \beta(\mathbf{P}_Y \times \widehat{\mathbf{n}}) + \gamma\widehat{\mathbf{n}} \times (\mathbf{P}_Y \times \widehat{\mathbf{n}})}{1 + \alpha \mathbf{P}_Y \cdot \widehat{\mathbf{n}}} \ .$$

Here $\mathbf{P}_B$ is defined in the rest system of the baryon, obtained by a Lorentz transformation along $\widehat{\mathbf{n}}$ from the hyperon rest frame, in which $\widehat{\mathbf{n}}$ and $\mathbf{P}_Y$ are defined.

An additional useful parameter ϕ is defined by

$$\beta = (1-\alpha^2)^{1/2}\,\sin\phi\ .$$

In the Listings, we compile α and ϕ for each decay, since these quantities are most closely related to experiment and are essentially uncorrelated. When necessary, we have changed the signs of reported values to agree with our sign conventions. In the Baryon Summary Table, we give α, ϕ, and Δ (defined below) with errors, and also give the value of γ without error.

Time-reversal invariance requires, in the absence of final-state interactions, that s and p be relatively real, and therefore that $\beta = 0$. However, for the decays discussed here, the final-state interaction is strong. Thus

$$s = |\,s\,|\,e^{i\delta_s} \text{ and } p = |\,p\,|\,e^{i\delta_p}\ ,$$

where δ_s and δ_p are the pion-baryon s- and p-wave strong interaction phase shifts. We then have

$$\beta = \frac{-2\,|\,s\,|\;|\,p\,|}{|\,s\,|^2 + |\,p\,|^2}\,\sin(\delta_s - \delta_p)\ .$$

One also defines $\Delta = -\tan^{-1}(\beta/\alpha)$. If T invariance holds, $\Delta = \delta_s - \delta_p$. For $\Lambda \rightarrow p\pi^-$ decay, the value of Δ may be compared with the s- and p-wave phase shifts in low-energy $\pi^- p$ scattering, and the results are consistent with T invariance.

Radiative hyperon decays

For the radiative decay of a polarized spin-1/2 hyperon, $B_i \rightarrow B_f\gamma$, the angular distribution of the direction $\widehat{p}$ of the final spin-1/2 baryon in the hyperon rest frame is

$$\frac{d\Gamma_\gamma}{d\Omega} = \frac{\Gamma_\gamma}{4\pi}\,(1 + \alpha_\gamma \widehat{p}\cdot\mathbf{P}_i)\ ,$$

where $\mathbf{P}_i$ is the hyperon polarization and the asymmetry parameter α_γ is

$$\alpha_\gamma = \frac{2\mathrm{Re}\left[g_1'(0)f_M^*(0)\right]}{|g_1'(0)|^2 + |f_M(0)|^2} \ .$$

Here $f_M = \dfrac{(m_i - m_f)}{(m_i + m_f)}\left[(m_i + m_f)f_2' - f_1'\right]$, where $f_1'(q^2)$, $f_2'(q^2)$, and $g_1'(q^2)$ are the $\Delta Q = 0$ analogs of the $|\Delta Q| = 1$ form factors defined above.

References

1. E.D. Commins and P.H. Bucksbaum, *Weak Interactions of Leptons and Quarks* (Cambridge University Press, Cambridge, England, 1983).
2. N. Cabibbo, Phys. Rev. Lett. **10**, 531 (1963).
3. M. Kobayashi and T. Maskawa, Prog. Theor. Phys. **49**, 652 (1973).
4. M.L. Goldberger and S.B. Treiman, Phys. Rev. **111**, 354 (1958).
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6. J.D. Jackson, S.B. Treiman, and H.W. Wyld, Jr., Phys. Rev. **106**, 517 (1957), and Nucl. Phys. **4**, 206 (1957).
7. Y. Yokoo, S. Suzuki, and M. Morita, Prog. Theor. Phys. **50**, 1894 (1973).

$n \to pe^-\nu$ DECAY PARAMETERS

See the above "Note on Baryon Decay Parameters." For discussions of recent results, see the references cited at the beginning of the section on the neutron mean life. For discussions of the values of the weak coupling constants g_A and g_V obtained using the neutron lifetime and asymmetry parameter A, comparisons with other methods of obtaining these constants, and implications for particle physics and for astrophysics, see DUBBERS 91 and WOOLCOCK 91. For tests of the $V-A$ theory of neutron decay, see EROZOLIMSKII 91B and MOSTOVOI 96.

g_A / g_V

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
−1.2670±0.0035 OUR AVERAGE	Error includes scale factor of 1.9. See the ideogram below.		
−1.274 ±0.003	ABELE 97D	SPEC	cold *n*, polarized

−1.266 ±0.004	LIAUD 97	TPC	*e* mom-*n* spin corr.
−1.2594±0.0038	[15] YEROZLIM... 97	CNTR	*e* mom-*n* spin corr.
−1.262 ±0.005	BOPP 86	SPEC	*e* mom-*n* spin corr.

• • • We do not use the following data for averages, fits, limits, etc. • • •

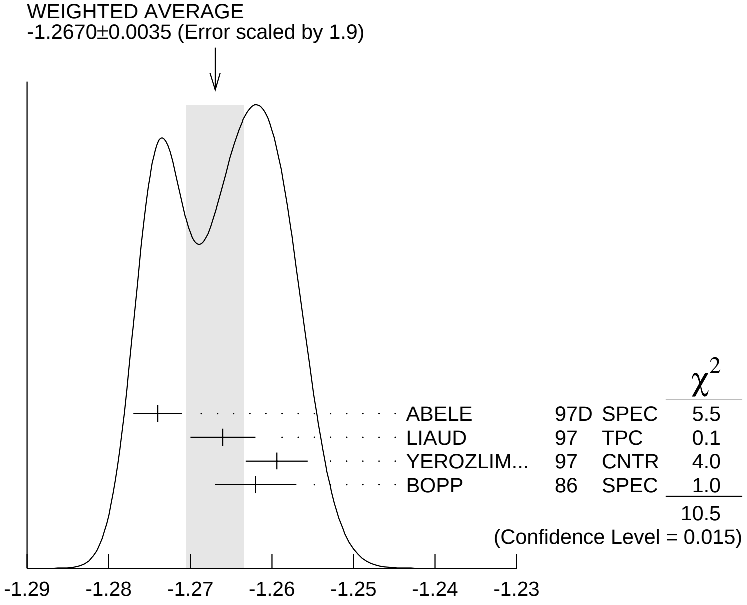
−1.266 ±0.004	SCHRECK... 95	TPC	See LIAUD 97
−1.2544±0.0036	EROZOLIM... 91	CNTR	See YEROZOLIMSKY 97
−1.226 ±0.042	MOSTOVOY 83	RVUE	
−1.261 ±0.012	[16] EROZOLIM... 79	CNTR	*e* mom-*n* spin corr.
−1.259 ±0.017	[16] STRATOWA 78	CNTR	proton recoil spectrum
−1.263 ±0.015	EROZOLIM... 77	CNTR	See EROZOLIMSKII 79
−1.250 ±0.036	[16] DOBROZE... 75	CNTR	See STRATOWA 78
−1.258 ±0.015	[17] KROHN 75	CNTR	*e* mom-*n* spin corr.
−1.263 ±0.016	[18] KROPF 74	RVUE	*n* decay alone
−1.250 ±0.009	[18] KROPF 74	RVUE	*n* decay + nuclear ft

[15] YEROZOLIMSKY 97 makes a correction to the EROZOLIMSKII 91 value.

[16] These experiments measure the absolute value of g_A/g_V only.

[17] KROHN 75 includes events of CHRISTENSEN 70.

[18] KROPF 74 reviews all data through 1972.



g_A / g_V

β ASYMMETRY PARAMETER *A*

This is the neutron-spin electron-momentum correlation coefficient. Unless otherwise noted, the values are corrected for radiative effects and weak magnetism.

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
−0.1162±0.0013 OUR AVERAGE	Error includes scale factor of 1.8. See the ideogram below.		
−0.1189±0.0012	ABELE 97D	SPEC	cold *n*, polarized

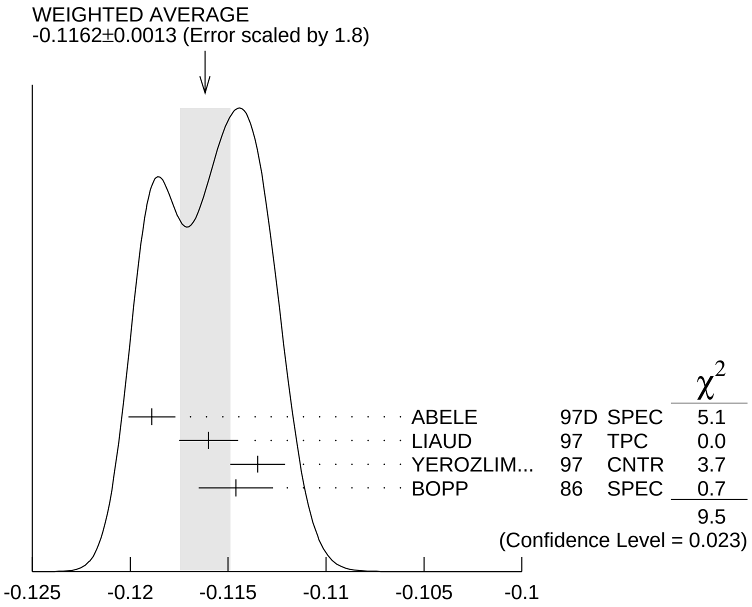
−0.1160±0.0009±0.0012	LIAUD 97	TPC	*e* mom-*n* spin corr.
−0.1135±0.0014	[19] YEROZLIM... 97	CNTR	*e* mom-*n* spin corr.
−0.1146±0.0019	BOPP 86	SPEC	

• • • We do not use the following data for averages, fits, limits, etc. • • •

−0.1160±0.0009±0.0011	SCHRECK... 95	TPC	See LIAUD 97
−0.1116±0.0014	EROZOLIM... 91	CNTR	See YEROZOLIMSKY 97
−0.114 ±0.005	[20] EROZOLIM... 79	CNTR	
−0.113 ±0.006	[20] KROHN 75	CNTR	

[19] YEROZOLIMSKY 97 makes a correction to the EROZOLIMSKII 91 value.

[20] These results are not corrected for radiative effects and weak magnetism, but the corrections are small compared to the errors.



β ASYMMETRY PARAMETER A

$\overline{\nu}$ ASYMMETRY PARAMETER *B*

This is the neutron-spin antineutrino-momentum correlation coefficient.

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.990 ±0.008 OUR AVERAGE			
0.9894±0.0083	KUZNETSOV 95	CNTR	Cold polarized neutrons
0.995 ±0.034	CHRISTENSEN 70	CNTR	
1.00 ±0.05	EROZOLIM... 70C	CNTR	

e-$\overline{\nu}$ ANGULAR CORRELATION COEFFICIENT *a*

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
−0.102 ±0.005 OUR AVERAGE			
−0.1017±0.0051	STRATOWA 78	CNTR	Proton recoil spectrum
−0.091 ±0.039	GRIGOREV 68	SPEC	Proton recoil spectrum

ϕ_{AV}, PHASE OF g_A RELATIVE TO g_V

Time reversal invariance requires this to be 0 or 180°.

VALUE (°)	*DOCUMENT ID*		*TECN*	*COMMENT*
180.07±0.18 OUR EVALUATION	Using the average value for quantity D given in the next data block and $\lambda \equiv g_A/g_V$ in $\sin\phi_{AV} = D(1+3\lambda^2)/2\lambda$.			
180.09±0.18 OUR AVERAGE				
179.71±0.39	EROZOLIM...	78	CNTR	Polarized neutrons
180.35±0.43	EROZOLIM...	74	CNTR	Polarized neutrons
180.14±0.22	STEINBERG	74	CNTR	Polarized neutrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
181.1 ±1.3	[21] KROPF	74	RVUE	*n* decay

[21] KROPF 74 reviews all data through 1972.

TRIPLE CORRELATION COEFFICIENT *D*

These are measurements of the component of *n* spin perpendicular to the decay plane in β decay. Should be zero if T invariance is not violated.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
$(-0.5 \pm 1.4) \times 10^{-3}$ OUR AVERAGE				
+ 0.0022±0.0030	EROZOLIM...	78	CNTR	Polarized neutrons
− 0.0027±0.0050	[22] EROZOLIM...	74	CNTR	Polarized neutrons
− 0.0011±0.0017	STEINBERG	74	CNTR	Polarized neutrons

[22] EROZOLIMSKII 78 says asymmetric proton losses and nonuniform beam polarization may give a systematic error up to 0.003, thus increasing the EROZOLIMSKII 74 error to 0.005. STEINBERG 74 and STEINBERG 76 estimate these systematic errors to be insignificant in their experiment.

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n REFERENCES

We have omitted some papers that have been superseded by later experiments. See our earlier editions.

ABELE	97D	PL B407 212	H. Abele+	(HEIDP, ILLG)
LIAUD	97	NP A612 53	+Schreckenbach, Kossakowski+	(ILLG, LAPP)
YEROZLIM...	97	PL B412 240	Yerozolimsky, Kuznetsov, Mostovoy+	(HARV, PNPI, KIAE)
ALTAREV	96	PAN 59 1152 Translated from YAF 59 1204.	+Borisov, Borovikova+	(PNPI)
BONDAREN...	96	JETPL 64 416 Translated from ZETFP 64 382.	Bondarenko, Morozov, Panin, Fomin+	(KIAE)
BYRNE	96	EPL 33 187	+Dawber, Habeck, Smidt+	(SUSS, ILLG)
MOSTOVOI	96	PAN 59 968 Translated from YAF 59 1013.		(KIAE)
NORMAN	96	PR D53 4086	+Bahcall, Goldhaber	(LBL, IAS, BNL)
IGNATOVICH	95	JETPL 62 1 Translated from ZETFP 62 3.		(JINR)
KOESTER	95	PR C51 3363	+Waschkowski, Mitsyna+	(MUNT, JINR, LATV)
KUZNETSOV	95	PRL 75 794	+Serebrov, Stepanenko+	(PNPI, KIAE, HARV, NIST)
SCHRECK...	95	PL B349 427	Schreckenbach, Liaud+	(MUNT, ILLG, LAPP)
BALDO-...	94	ZPHY C63 409	Baldo-Ceolin, Benetti+	(HEID, ILLG, PADO, PAVI)
DIFILIPPO	94	PRL 73 1481	+Natarajan, Boyce, Pritchard	(MIT)
Also	93	PRL 71 1998	Natarajan, Boyce, DiFilippo, Pritchard	(MIT)
GOLUB	94	PRPL 237C 1	+Lamoreaux	(HAHN, WASH)
MAMPE	93	JETPL 57 82 Translated from ZETFP 57 77.	+Bondarenko, Morozov+	(KIAE)
PENDLEBURY	93	ARNPS 43 687		(ILLG)
ALTAREV	92	PL B276 242	+Borisov, Borovikova, Ivanov+	(PNPI)
NESVIZHEV...	92	JETP 75 405 Translated from ZETF 102 740.	Nesvizhevskii, Serebrov, Tal'daev+	(PNPI, JINR)

SCHRECK...	92	JPG 18 1	Schreckenbach, Mampe	(ILLG)
ALBERICO	91	NP A523 488	+de Pace, Pignone	(TORI)
DUBBERS	91	NP A527 239c		(ILLG)
Also	90	EPL 11 195	Dubbers, Mampe, Doehner	(ILLG, HEID)
EROZOLIM...	91	PL B263 33	Erozolimskii, Kuznetsov, Stepanenko, Kuida+	(PNPI, KIAE)
Also	90	SJNP 52 999 Translated from YAF 52 1583.	Erozolimskii, Kuznetsov, Stepanenko, Kuida+	(PNPI, KIAE)
EROZOLIM...	91B	SJNP 53 260 Translated from YAF 53 418.	Erozolimskii, Mostovoi	(KIAE)
SCHMIEDM...	91	PRL 66 1015	Schmiedmayer, Riehs, Harvey, Hill	(TUW, ORNL)
WOOLCOCK	91	MPL A6 2579		(CANB)
ALFIMENKOV	90	JETPL 52 373 Translated from ZETFP 52 984.	+Varlamov, Vasil'ev, Gudkov+	(PNPI, JINR)
BALDO-...	90	PL B236 95	Baldo-Ceolin, Benetti, Bitter+	(PADO, PAVI, HEIDP, ILLG)
BERGER	90	PL B240 237	+Froehlich, Moench, Nisius+	(FREJUS Collab.)
BRESSI	90	NC 103A 731	+Calligarich, Cambiaghi+	(PAVI, ROMA, MILA)
BYRNE	90	PRL 65 289	+Dawber, Spain, Williams+	(SUSS, NBS, SCOT, CBNM)
FREEDMAN	90	CNPP 19 209		(ANL)
GREEN	90	JPG 16 L75	+Thompson	(RAL)
RAMSEY	90	ARNPS 40 1		(HARV)
ROSE	90	PL B234 460	+Zurmuehl, Rullhusen, Ludwig+	(GOET, MPCM, MANZ)
ROSE	90B	NP A514 621	+Zurmuehl, Rullhusen, Ludwig+	(GOET, MPCM)
SMITH	90	PL B234 191	+Crampin+	(SUSS, RAL, HARV, WASH, ILLG, MUNT)
BRESSI	89	ZPHY C43 175	+Calligarich, Cambiaghi+	(INFN, MILA, PAVI, ROMA)
DOVER	89	NIM A284 13	+Gal, Richard	(BNL, HEBR, ISNG)
EROZOLIM...	89	NIM A284 89	Erozolimskii	(PNPI)
KOSSAKOW...	89	NP A503 473	Kossakowski, Grivot+	(LAPP, SAVO, ISNG, ILLG)
MAMPE	89	PRL 63 593	+Ageron, Bates, Pendlebury, Steyerl	(ILLG, RISL, SUSS, URI)
MOHAPATRA	89	NIM A284 1		(UMD)
PAUL	89	ZPHY C45 25	+Anton, Paul, Paul, Mampe	(BONN, WUPP, MPIH, ILLG)
SCHMIEDM...	89	NIM A284 137	Schmiedmayer, Rauch, Riehs	(WIEN)
BAUMANN	88	PR D37 3107	+Gaehler, Kalus, Mampe	(BAYR, MUNI, ILLG)
KOESTER	88	ZPHY A329 229	+Waschkowski, Meier	(MUNI, MUNT)
LAST	88	PRL 60 995	+Arnold, Doehner, Dubbers+	(HEIDP, ILLG, ANL)
SCHMIEDM...	88	PRL 61 1065	Schmiedmayer, Rauch, Riehs	(TUW)
Also	88B	PRL 61 2509 erratum	Schmiedmayer, Rauch, Riehs	(TUW)
SPIVAK	88	JETP 67 1735 Translated from ZETF 94 1.		(KIAE)
COHEN	87	RMP 59 1121	+Taylor	(RISC, NBS)
ALTAREV	86	JETPL 44 460 Translated from ZETFP 44 360.	+Borisov, Borovikova, Brandin, Egorov+	(PNPI)
BOPP	86	PRL 56 919	+Dubbers, Hornig, Klemt, Last+	(HEIDP, ANL, ILLG)
Also	88	ZPHY C37 179	Klemt, Bopp, Hornig, Last+	(HEIDP, ANL, ILLG)
CRESTI	86	PL B177 206	+Pasquali, Peruzzo, Pinori, Sartori	(PADO)
Also	88	PL B200 587 erratum	Cresti, Pasquali, Peruzzo, Pinori, Sartori	(PADO)
GREENE	86	PRL 56 819	+Kessler, Deslattes, Boerner	(NBS, ILLG)
KOSVINTSEV	86	JETPL 44 571 Translated from ZETFP 44 444.	+Morozov, Terekhov	(KIAE)
TAKITA	86	PR D34 902	+Arisaka, Kajita, Kifune+	(KEK, TOKY+)
DOVER	85	PR C31 1423	+Gal, Richard	(BNL)
FIDECARO	85	PL 156B 122	+Lanceri+	(CERN, ILLG, PADO, RAL, SUSS)
PARK	85B	NP B252 261	+Blewitt, Cortez, Foster+	(IMB Collab.)
BATTISTONI	84	PL 133B 454	+Bellotti, Bologna, Campana+	(NUSEX Collab.)
JONES	84	PRL 52 720	+Bionta, Blewitt, Bratton+	(IMB Collab.)
PENDLEBURY	84	PL 136B 327	+Smith, Golub, Byrne+	(SUSS, HARV, RAL, ILLG)
CHERRY	83	PRL 50 1354	+Lande, Lee, Steinberg, Cleveland	(PENN, BNL)
DOVER	83	PR D27 1090	+Gal, Richards	(BNL)
KABIR	83	PRL 51 231		(HARV)
MOSTOVOY	83	JETPL 37 196 Translated from ZETFP 37 162.		(KIAE)
ROY	83	PR D28 1770	+Vaidya, Ephraim, Datar, Bhatki+	(TATA)
VAIDYA	83	PR D27 486	+Roy, Ephraim, Datar, Bhattacherjee	(TATA)
GAEHLER	82	PR D25 2887	+Kalus, Mampe	(BAYR, ILLG)
GREENE	82	Metrologia 18 93	+	(YALE, HARV, ILLG, SUSS, ORNL, CENG)
ALTAREV	81	PL 102B 13	+Borisov, Borovikova, Brandin, Egorov+	(PNPI)
BARABANOV	80	JETPL 32 359 Translated from ZETFP 32 384.	+Veretenkin, Gavrin+	(PNPI)
BYRNE	80	PL 92B 274	+Morse, Smith, Shaikh, Green, Greene	(SUSS, RL)
KOSVINTSEV	80	JETPL 31 236 Translated from ZETFP 31 257.	+Kushnir, Morozov, Terekhov	(JINR)
MOHAPATRA	80	PRL 44 1316	+Marshak	(CUNY, VPI)
ALTAREV	79	JETPL 29 730 Translated from ZETFP 29 794.	+Borisov, Brandin, Egorov, Ezhov, Ivanov+	(PNPI)

EROZOLIM...	79	SJNP 30 356 Translated from YAF 30 692.	Erozolimskii, Frank, Mostovoy+	(KIAE)
NORMAN	79	PRL 43 1226	+Seamster	(WASH)
BONDAREN...	78	JETPL 28 303 Translated from ZETFP 28 328.	Bondarenko, Kurguzov, Prokofev+	(KIAE)
Also	82	Smolenice Conf.	Bondarenko	(KIAE)
EROZOLIM...	78	SJNP 28 48 Translated from YAF 28 98.	Erozolimskii, Mostovoy, Fedunin, Frank+	(KIAE)
STRATOWA	78	PR D18 3970	+Dobrozemsky, Weinzierl	(SEIB)
EROZOLIM...	77	JETPL 23 663 Translated from ZETFP 23 720.	Erozolimskii, Frank, Mostovoy+	(KIAE)
STEINBERG	76	PR D13 2469	+Liaud, Vignon, Hughes	(YALE, ISNG)
DOBROZE...	75	PR D11 510	Dobrozemsky, Kerschbaum, Moraw, Paul+	(SEIB)
KROHN	75	PL 55B 175	+Ringo	(ANL)
EROZOLIM...	74	JETPL 20 345 Translated from ZETFP 20 745.	Erozolimskii, Mostovoy, Fedunin, Frank+	
KROPF	74	ZPHY 267 129	+Paul	(LINZ)
Also	70	NP A154 160	Paul	(VIEN)
STEINBERG	74	PRL 33 41	+Liaud, Vignon, Hughes	(YALE, ISNG)
COHEN	73	JPCRD 2 663	+Taylor	(RISC, NBS)
CHRISTENSEN	72	PR D5 1628	+Nielson, Bahnsen, Brown+	(RISO)
CHRISTENSEN	70	PR C1 1693	+Krohn, Ringo	(ANL)
EROZOLIM...	70C	PL 33B 351	Erozolimskii, Bondarenko, Mostovoy, Obinyakov+	(KIAE)
GRIGOREV	68	SJNP 6 239 Translated from YAF 6 329.	Grigor'ev, Grishin, Vladimirsky, Nikolaevskii+	(ITEP)