\[ I(J^P) = \frac{1}{2}(\frac{1}{2}^+) \] Status: \( \ast\ast\ast\ast \)

We have omitted some results that have been superseded by later experiments.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


### \( n \) MASS (atomic mass units u)

The mass is known much more precisely in u (atomic mass units) than in MeV. See the next data block.

<table>
<thead>
<tr>
<th>VALUE (u)</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00866491588±0.00000000049</td>
<td>MOHR</td>
<td>16</td>
<td>RVUE</td>
</tr>
<tr>
<td>1.00866491600±0.00000000034</td>
<td>MOHR</td>
<td>12</td>
<td>RVUE</td>
</tr>
<tr>
<td>1.00866491597±0.00000000043</td>
<td>MOHR</td>
<td>08</td>
<td>RVUE</td>
</tr>
<tr>
<td>1.00866491560±0.000000000055</td>
<td>MOHR</td>
<td>05</td>
<td>RVUE</td>
</tr>
<tr>
<td>1.00866491578±0.000000000055</td>
<td>MOHR</td>
<td>99</td>
<td>RVUE</td>
</tr>
<tr>
<td>1.008665904±0.00000000014</td>
<td>COHEN</td>
<td>87</td>
<td>RVUE</td>
</tr>
</tbody>
</table>

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

### \( n \) MASS (MeV)

The mass is known much more precisely in u (atomic mass units) than in MeV. The conversion from u to MeV, \( 1 \text{ u} = 931.494 0054(57) \) MeV/c\(^2\) (MOHR 16, the 2014 CODATA value), involves the relatively poorly known electronic charge.

<table>
<thead>
<tr>
<th>VALUE (MeV)</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>939.5654133±0.0000058</td>
<td>MOHR</td>
<td>16</td>
<td>RVUE</td>
</tr>
<tr>
<td>939.565379 ±0.000021</td>
<td>MOHR</td>
<td>12</td>
<td>RVUE</td>
</tr>
<tr>
<td>939.565346 ±0.000023</td>
<td>MOHR</td>
<td>08</td>
<td>RVUE</td>
</tr>
<tr>
<td>939.565360 ±0.000081</td>
<td>MOHR</td>
<td>05</td>
<td>RVUE</td>
</tr>
<tr>
<td>939.565331 ±0.000037</td>
<td>KESSLER</td>
<td>99</td>
<td>SPEC</td>
</tr>
<tr>
<td>939.565330 ±0.000038</td>
<td>MOHR</td>
<td>99</td>
<td>RVUE</td>
</tr>
<tr>
<td>939.56565 ±0.000028</td>
<td>DIFILIPPO</td>
<td>94</td>
<td>TRAP</td>
</tr>
<tr>
<td>939.56563 ±0.000028</td>
<td>COHEN</td>
<td>87</td>
<td>RVUE</td>
</tr>
<tr>
<td>939.56564 ±0.000028</td>
<td>GREENE</td>
<td>86</td>
<td>SPEC</td>
</tr>
<tr>
<td>939.5731 ±0.00027</td>
<td>COHEN</td>
<td>73</td>
<td>RVUE</td>
</tr>
</tbody>
</table>

1 We use the 1998 CODATA u-to-MeV conversion factor (see the heading above) to get this mass in MeV from the much more precisely measured KESSLER 99 value of 1.00866491637 ± 0.00000000082 u.

2 The mass is known much more precisely in u: \( m = 1.0086649235 \pm 0.0000000023 \) u. We use the 1986 CODATA conversion factor 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: \( m = 1.008664919 \pm 0.00000014 \) u.

HTTP://PDG.LBL.GOV Page 1 Created: 8/2/2019 16:43
\( \pi \) MASS

\[
\begin{array}{cccc}
\text{VALUE (MeV)} & \text{EVTS} & \text{DOCUMENT ID} & \text{TECN} \\
939.485 \pm 0.051 & 59 & 1 & \text{CRESTI 86 HBC} \\
\end{array}
\]

\( (m_n - m_\pi) / m_n \)

A test of CPT invariance. Calculated from the \( n \) and \( \pi \) masses, above.

\[
\begin{array}{cccc}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} \\
(9 \pm 6) \times 10^{-5} & 1 & \text{RVUE 2014 CODATA value} \\
\end{array}
\]

\( m_n - m_p \)

\[
\begin{array}{cccc}
\text{VALUE (MeV)} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
1.29333205 \pm 0.00000051 & 1 & \text{MOHR 16 RVUE} & \text{2014 CODATA value} \\
1.29333217 \pm 0.00000042 & 2 & \text{MOHR 12 RVUE} & \text{2010 CODATA value} \\
1.29333214 \pm 0.00000043 & 3 & \text{MOHR 08 RVUE} & \text{2006 CODATA value} \\
1.2933317 \pm 0.0000005 & 4 & \text{MOHR 05 RVUE} & \text{2002 CODATA value} \\
1.2933318 \pm 0.0000005 & 5 & \text{MOHR 99 RVUE} & \text{1998 CODATA value} \\
1.293318 \pm 0.0000009 & 6 & \text{COHEN 86 RVUE} & \text{1986 CODATA value} \\
1.293328 \pm 0.0000072 & \text{GREENE 86 SPEC} & \text{np \to d\gamma} \\
1.293429 \pm 0.000036 & \text{COHEN 73 RVUE} & \text{1973 CODATA value} \\
\end{array}
\]

1 The 2014 CODATA mass difference in \( u \) is \( m_n - m_p = 1.00138844990(51) \times 10^{-3} u \).

2 The 2010 CODATA mass difference in \( u \) is \( m_n - m_p = 1.38844919(45) \times 10^{-3} u \).

3 Calculated by us from the MOHR 08 ratio \( m_n / m_p = 1.00137841918(46) \). In \( u \), \( m_n - m_p = 1.38844920(46) \times 10^{-3} u \).

4 Calculated by us from the MOHR 05 ratio \( m_n / m_p = 1.00137841870 \pm 0.0000000058 \). In \( u \), \( m_n - m_p = (1.3884487 \pm 0.0000006) \times 10^{-3} u \).

5 Calculated by us from the MOHR 99 ratio \( m_n / m_p = 1.00137841887 \pm 0.0000000058 \). In \( u \), \( m_n - m_p = (1.3884489 \pm 0.0000006) \times 10^{-3} u \).

6 Calculated by us from the COHEN 87 ratio \( m_n / m_p = 1.001378404 \pm 0.00000009 \). In \( u \), \( m_n - m_p = 0.001388434 \pm 0.00000009 u \).

\( n \) MEAN LIFE

Limits on lifetimes for bound neutrons are given in the section “p PARTIAL MEAN LIVES.”

We average seven of the best eight measurements, those made with ultracold neutrons (UCN’s). If we include the one in-beam measurement with a comparable error (YUE 13), we get 879.6 \( \pm \) 0.8 s, where the scale factor is now 2.0.

For a recent discussion of the long-standing disagreement between in-beam and UCN results, see CZARNECKI 18 (Physical Review Letters 120)

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

1. PATTIE 18 uses a new technique, with a semi-toroidal magneto-gravitational asymmetric trap and a novel in situ n-detector.

2. ARZUMANOV 15 is a reanalysis of their 2008–2010 dataset, with improved systematic corrections of ARZUMANOV 00 and ARZUMANOV 12.

3. STEYERL 12 is a detailed reanalysis of neutron storage loss corrections to the raw data of MAMPE 89, and it replaces that value.

4. YUE 13 differs from NICO 05 in that a different and better method was used to measure the neutron density in the fiducial volume. This shifted the lifetime by +1.4 seconds and reduced the previously largest source of systematic uncertainty by a factor of five.

5. ARZUMANOV 12 reanalyzes its systematic corrections in ARZUMANOV 00 and obtains this corrected value.

6. IGNA TOVICH 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.

7. The NESVIZHEVSKII 92 measurement has been withdrawn by A. Serebrov.

8. The BYRNE 80 measurement has been withdrawn (J. Byrne, private communication, 1990).
WEIGHTED AVERAGE
879.4±0.6 (Error scaled by 1.6)

\[
\begin{align*}
\text{EZHOV} & \quad 18 \quad \text{CNTR} \quad 0.3 \\
PATTIE & \quad 18 \quad \text{CNTR} \quad 4.2 \\
SEREBROV & \quad 18 \quad \text{CNTR} \quad 5.4 \\
ARZUMANOV & \quad 15 \quad \text{CNTR} \quad 0.5 \\
STEYERL & \quad 12 \quad \text{CNTR} \quad 2.4 \\
PICHLMACHER & \quad 10 \quad \text{CNTR} \quad 0.6 \\
SEREBROV & \quad 05 \quad \text{CNTR} \quad 1.2 \\
\end{align*}
\]

14.6

(Confidence Level = 0.023)

neutron mean life (s)

\textbf{n MAGNETIC MOMENT}

See the “Note on Baryon Magnetic Moments” in the \(\Lambda\) Listings.

\begin{itemize}
\item \textbf{VALUE} \( (\mu_{n}) \)
\item We do not use the following data for averages, fits, limits, etc.
\item \( -1.91304273 \pm 0.00000045 \)
\item MÖHR 16 RVUE 2014 CODATA value
\item \( -1.91304272 \pm 0.00000045 \)
\item MÖHR 12 RVUE 2010 CODATA value
\item \( -1.91304273 \pm 0.00000045 \)
\item MÖHR 08 RVUE 2006 CODATA value
\item \( -1.91304273 \pm 0.00000045 \)
\item MÖHR 05 RVUE 2002 CODATA value
\item \( -1.91304272 \pm 0.00000045 \)
\item MÖHR 99 RVUE 1998 CODATA value
\item \( -1.91304275 \pm 0.00000045 \)
\item COHEN 87 RVUE 1986 CODATA value
\item \( -1.91304277 \pm 0.00000048 \)
\item \textsuperscript{1} COHEN 82 MRS
\end{itemize}

\(1\) 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).

\textbf{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, GOLUB 94, and LAMOREAUX 09 for reviews.

The results are upper limits on \(|d_n|\).

\begin{itemize}
\item \textbf{VALUE} \((10^{-25} \text{ e cm})\)
\item \textbf{CL}\% 90
\item \textbf{DOCUMENT ID} PENDLEBURY 15
\item \textbf{TECN} MRS
\item \textbf{COMMENT} \(d = ( -0.21 \pm 1.82 ) \times 10^{-26}\)
\end{itemize}
We do not use the following data for averages, fits, limits, etc. • • •

< 0.22 95 SAHOO 17 199Hg atom EDM + theory
< 0.16 95 GRANER 16 MRS 199Hg atom EDM + theory
< 0.55 90 SEREBROV 15 MRS UCN's, $h\nu = 2\mu B \pm 2d_n E$
< 0.55 90 SEREBROV 14 MRS See SEREBROV 15
< 0.29 90 BAKER 06 MRS See PENDLEBURY 15
< 0.63 90 HARRIS 99 MRS $d = (-0.1 \pm 0.36) \times 10^{-25}$
< 0.97 90 ALTAREV 96 MRS See SEREBROV 14
< 1.10 95 ALTAREV 92 MRS See ALTAREV 96
< 1.20 95 SMITH 90 MRS See HARRIS 99
< 2.60 95 ALTAREV 86 MRS $d = (-1.4 \pm 0.6) \times 10^{-25}$
0.3 ± 4.8 PENDLEBURY 84 MRS Ultracold neutrons
< 6.00 90 ALTAREV 81 MRS $d = (2.1 \pm 2.4) \times 10^{-25}$
<16.00 90 ALTAREV 79 MRS $d = (4.0 \pm 7.5) \times 10^{-25}$

1 SAHOO 17 develops theory to calculate this limit from the measured limit by GRANER 16 of the 199Hg atom EDM.

2 SEREBROV 14 includes the data of ALTAREV 96.

3 LAMOREAUX 07 faults BAKER 06 for not including in the estimate of systematic error an effect due to the Earth’s rotation. BAKER 07 replies (1) that the effect was included implicitly in the analysis and (2) that further analysis confirms that the BAKER 06 limit is correct as is. See also SILENKO 07.

4 This HARRIS 99 result includes the result of SMITH 90. However, the averaging of the results of these two experiments has been criticized by LAMOREAUX 00.

### n MEAN-SQUARE CHARGE RADIUS

The mean-square charge radius of the neutron, $\langle r^2_n \rangle$, is related to the neutron-electron scattering length $b_{ne}$ by $\langle r^2_n \rangle = 3(m_e a_0/m_n)b_{ne}$, where $m_e$ and $m_n$ are the masses of the electron and neutron, and $a_0$ is the Bohr radius. Numerically, $\langle r^2_n \rangle = 86.34 b_{ne}$, if we use $a_0$ for a nucleus with infinite mass.

<table>
<thead>
<tr>
<th>VALUE (fm²)</th>
<th>DOCUMENT ID</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>−0.1161 ± 0.0022 OUR AVERAGE</td>
<td>Error includes scale factor of 1.3. See the ideogram below.</td>
<td></td>
</tr>
<tr>
<td>−0.115 ± 0.002 ± 0.003</td>
<td>KOPECKY 97</td>
<td>ne scattering (Pb)</td>
</tr>
<tr>
<td>−0.124 ± 0.003 ± 0.005</td>
<td>KOPECKY 97</td>
<td>ne scattering (Bi)</td>
</tr>
<tr>
<td>−0.114 ± 0.003</td>
<td>KOESTER 95</td>
<td>ne scattering (Pb, Bi)</td>
</tr>
<tr>
<td>−0.134 ± 0.009</td>
<td>ALEKSANDR...86</td>
<td>ne scattering (Bi)</td>
</tr>
<tr>
<td>−0.115 ± 0.003</td>
<td>KROHN 73</td>
<td>ne scattering (Ne, Ar, Kr, Xe)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>VALUE (fm²)</th>
<th>DOCUMENT ID</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>−0.117 + 0.007</td>
<td>BELUSHKIN 07</td>
<td>Dispersion analysis</td>
</tr>
<tr>
<td>−0.113 ± 0.003 ± 0.004</td>
<td>KOPECKY 95</td>
<td>ne scattering (Pb)</td>
</tr>
<tr>
<td>−0.114 ± 0.003</td>
<td>KOESTER 86</td>
<td>ne scattering (Pb, Bi)</td>
</tr>
<tr>
<td>−0.118 ± 0.002</td>
<td>KOESTER 76</td>
<td>ne scattering (Pb)</td>
</tr>
<tr>
<td>−0.120 ± 0.002</td>
<td>KOESTER 76</td>
<td>ne scattering (Bi)</td>
</tr>
<tr>
<td>−0.116 ± 0.003</td>
<td>KROHN 66</td>
<td>ne scattering (Ne, Ar, Kr, Xe)</td>
</tr>
</tbody>
</table>

1 This value is as corrected by KOESTER 76.
n mean-square charge radius

n MAGNETIC RADIUS

This is the rms magnetic radius, \( \sqrt{\langle r_M^2 \rangle} \).

<table>
<thead>
<tr>
<th>VALUE (fm)</th>
<th>DOCUMENT ID</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.864 ± 0.009</td>
<td>OUR AVERAGE</td>
<td></td>
</tr>
<tr>
<td>0.89 ± 0.03</td>
<td>EPSTEIN</td>
<td>Using ( e p, e n, \pi \pi ) data</td>
</tr>
<tr>
<td>0.862 ± 0.009</td>
<td>BELUSHKIN</td>
<td>Dispersion analysis</td>
</tr>
</tbody>
</table>

n ELECTRIC POLARIZABILITY \( \alpha_n \)

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

For very complete reviews of the polarizability of the nucleon and Compton scattering, see SCHUMACHER 05 and GRIESSHAMMER 12.

<table>
<thead>
<tr>
<th>VALUE ( (10^{-4} \text{ fm}^3) )</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.8 ± 1.1 ( \text{OUR AVERAGE} )</td>
<td>MYERS</td>
<td>CNTR</td>
<td>( \gamma d \rightarrow \gamma d )</td>
</tr>
<tr>
<td>11.55 ± 1.25 ± 0.8</td>
<td>KOSsert</td>
<td>CNTR</td>
<td>( \gamma d \rightarrow \gamma p n )</td>
</tr>
<tr>
<td>12.5 ± 1.6</td>
<td>SCHMIEDM...</td>
<td>CNTR</td>
<td>( n ) Pb transmission</td>
</tr>
<tr>
<td>12.0 ± 1.5 ± 2.0</td>
<td>ROSE</td>
<td>CNTR</td>
<td>( \gamma d \rightarrow \gamma n p )</td>
</tr>
<tr>
<td>10.7 + 3.3 ± 10.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
We do not use the following data for averages, fits, limits, etc. ⋆ ⋆ ⋆

<table>
<thead>
<tr>
<th>VALUE (10^{-4} fm^3)</th>
<th>DOCUMENT ID</th>
<th>TECH</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.8 ± 2.4 ± 3.0</td>
<td>2 LUNDIN 03</td>
<td>CNTR</td>
<td>γd → γd</td>
</tr>
<tr>
<td>13.6</td>
<td>3 KOLB 00</td>
<td>CNTR</td>
<td>γd → γnp</td>
</tr>
<tr>
<td>0.0 ± 5.0</td>
<td>4 KOESTER 95</td>
<td>CNTR</td>
<td>n Pb, n Bi transmission</td>
</tr>
<tr>
<td>11.7 ± 4.3 −11.7</td>
<td>ROSE 90 CNTR</td>
<td></td>
<td>See ROSE 90B</td>
</tr>
<tr>
<td>8 ± 10</td>
<td>KOESTER 88</td>
<td>CNTR</td>
<td>n Pb, n Bi transmission</td>
</tr>
<tr>
<td>12 ± 10</td>
<td>SCHMIEDM... 88 CNTR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 KOSsert 03 gets α_n − β_n = (9.8 ± 3.6_+2.1_-1.1 ± 2.2) × 10^{-4} fm^3, and uses α_n + β_n = (15.2 ± 0.5) × 10^{-4} fm^3 from LEVCHUK 00. Thus the errors on α_n and β_n are anti-correlated.

2 LUNDIN 03 measures α_N − β_N = (6.4 ± 2.4) × 10^{-4} fm^3 and uses accurate values for α_p and α_p and a precise sum-rule result for α_n + β_n. The second error is a model uncertainty, and errors on α_n and β_n are anticorrelated. The data from this paper are included in the analysis of MYERS 14.

3 KOLB 00 obtains this value with a lower limit of 7.6 × 10^{-4} fm^3 but no upper limit from this experiment alone. Combined with results of ROSE 90, the 1-σ range is (7.6−14.0) × 10^{-4} fm^3.

4 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 MAGNETIC POLARIZABILITY β_n

<table>
<thead>
<tr>
<th>VALUE (10^{-4} fm^3)</th>
<th>DOCUMENT ID</th>
<th>TECH</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7 ± 1.2 OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.65 ± 1.25 ± 0.8</td>
<td>MYERS 14</td>
<td>CNTR</td>
<td>γd → γd</td>
</tr>
<tr>
<td>2.7 ± 1.8 ± 1.3</td>
<td>1 KOSsert 03</td>
<td>CNTR</td>
<td>γd → γp n</td>
</tr>
<tr>
<td>6.5 ± 2.4 ± 3.0</td>
<td>2 LUNDIN 03</td>
<td>CNTR</td>
<td>γd → γd</td>
</tr>
</tbody>
</table>

1 KOSsert 03 gets α_n − β_n = (9.8 ± 3.6_+2.1_-1.1 ± 2.2) × 10^{-4} fm^3, and uses α_n + β_n = (15.2 ± 0.5) × 10^{-4} fm^3 from LEVCHUK 00. Thus the errors on α_n and β_n are anti-correlated.

2 LUNDIN 03 measures α_N − β_N = (6.4 ± 2.4) × 10^{-4} fm^3 and uses accurate values for α_p and α_p and a precise sum-rule result for α_n + β_n. The second error is a model uncertainty, and errors on α_n and β_n are anticorrelated.

3 KOLB 00 obtains this value with an upper limit of 7.6 × 10^{-4} fm^3 but no lower limit from this experiment alone. Combined with results of ROSE 90, the 1-σ range is (1.2−7.6) × 10^{-4} fm^3.

n CHARGE

See also “|q_p + q_e|/e” in the proton Listings.

<table>
<thead>
<tr>
<th>VALUE (10^{-21} e)</th>
<th>DOCUMENT ID</th>
<th>TECH</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>− 0.2± 0.8 OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>− 0.1 ± 1.1</td>
<td>1 BRESSI 11</td>
<td></td>
<td>Neutrality of SF_6</td>
</tr>
<tr>
<td>− 0.4 ± 1.1</td>
<td>2 BAUMANN 88</td>
<td></td>
<td>Cold n deflection</td>
</tr>
</tbody>
</table>

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

−15 ± 22

3 GAELHER 82 CNTR Cold n deflection
As a limit, this BRESSI 11 value is $< 1 \times 10^{-21}$ e.

The BAUMANN 88 error $\pm 1.1$ gives the 68% CL limits about the the value $-0.4$.

The GAEHLER 82 error $\pm 22$ gives the 90% CL limits about the the value $-15$.

**LIMIT ON $n\pi$ OSCILLATIONS**

**Mean Time for $n\pi$ Transition in Vacuum**

A test of $\Delta B=2$ baryon number nonconservation. MOHAPATRA 80 and MOHAPATRA 89 discuss the theoretical motivations for looking for $n\pi$ 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, ALBERICO 91, and GAL 00 for discussions. Direct searches for $n \to \pi$ transitions using reactor neutrons are cleaner but give somewhat poorer limits. We include limits for both free and bound neutrons in the Summary Table. See MOHAPATRA 09 and PHILLIPS 16 for recent reviews.

<table>
<thead>
<tr>
<th>VALUE (s)</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&gt;2.7 \times 10^8$</td>
<td>90</td>
<td>ABE</td>
<td>CNTR</td>
<td>$n$ bound in oxygen</td>
</tr>
<tr>
<td>$&gt;8.6 \times 10^7$</td>
<td>90</td>
<td>BALDO-...</td>
<td>CNTR</td>
<td>Reactor (free) neutrons</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>VALUE (s)</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&gt;1.37 \times 10^8$</td>
<td>90</td>
<td>1 AHARMIM</td>
<td>SNO</td>
<td>$n$ bound in deuteron</td>
</tr>
<tr>
<td>$&gt;1.3 \times 10^8$</td>
<td>90</td>
<td>CHUNG</td>
<td>SOU2</td>
<td>$n$ bound in iron</td>
</tr>
<tr>
<td>$&gt;1 \times 10^7$</td>
<td>90</td>
<td>BALDO-...</td>
<td>CNTR</td>
<td>See BALDO-CEOLIN 94</td>
</tr>
<tr>
<td>$&gt;1.2 \times 10^8$</td>
<td>90</td>
<td>BERGER</td>
<td>FREJ</td>
<td>$n$ bound in iron</td>
</tr>
<tr>
<td>$&gt;4.9 \times 10^5$</td>
<td>90</td>
<td>BRESSI</td>
<td>CNTR</td>
<td>Reactor neutrons</td>
</tr>
<tr>
<td>$&gt;4.7 \times 10^5$</td>
<td>90</td>
<td>BRESSI</td>
<td>CNTR</td>
<td>See BRESSI 90</td>
</tr>
<tr>
<td>$&gt;1.2 \times 10^8$</td>
<td>90</td>
<td>TAKITA</td>
<td>CNTR</td>
<td>$n$ bound in oxygen</td>
</tr>
<tr>
<td>$&gt;1 \times 10^6$</td>
<td>90</td>
<td>FIDECARO</td>
<td>CNTR</td>
<td>Reactor neutrons</td>
</tr>
<tr>
<td>$&gt;8.8 \times 10^7$</td>
<td>90</td>
<td>PARK</td>
<td>CNTR</td>
<td></td>
</tr>
<tr>
<td>$&gt;3 \times 10^7$</td>
<td></td>
<td>BATTISTONI</td>
<td>NUSX</td>
<td></td>
</tr>
<tr>
<td>$&gt;0.27-1.1 \times 10^8$</td>
<td>90</td>
<td>JONES</td>
<td>CNTR</td>
<td></td>
</tr>
<tr>
<td>$&gt;2 \times 10^7$</td>
<td></td>
<td>CHERRY</td>
<td>CNTR</td>
<td></td>
</tr>
</tbody>
</table>

1 The AHARMIM 17 value is an unbounded limit (it does not assume a positive lifetime). The bounded limit is $1.23 \times 10^8$ sec.

**LIMIT ON $n\pi'$ OSCILLATIONS**

Lee and Yang (LEE 56) proposed the existence of mirror world in an attempt to restore global parity symmetry. A possible candidate for dark matter. Limits depend on assumptions about fields $B$ and $B'$: See BEREZHIANI 18 for recent discussion.

<table>
<thead>
<tr>
<th>VALUE (s)</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&gt;448$</td>
<td>90</td>
<td>SEREBROV</td>
<td>CNTR</td>
<td>Assumes $B' &lt; 100$ nT</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>VALUE (s)</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&gt;17$</td>
<td>95</td>
<td>1 BEREZHIANI</td>
<td>UCN</td>
<td>scan of $B$ field</td>
</tr>
<tr>
<td>$&gt;12$</td>
<td>95</td>
<td>2 ALTAREV</td>
<td>UCN</td>
<td>scan $0 \leq B \leq 12.5 \mu T$</td>
</tr>
<tr>
<td>$&gt;414$</td>
<td>90</td>
<td>SEREBROV</td>
<td>UCN</td>
<td>$B$ field on &amp; off</td>
</tr>
<tr>
<td>$&gt;103$</td>
<td>95</td>
<td>BAN</td>
<td>UCN</td>
<td>$B$ field on &amp; off</td>
</tr>
</tbody>
</table>

HTTP://PDG.LBL.GOV  Page 8  Created: 8/2/2019 16:43
1 The $B$ field was set to (0.09, 0.12, 0.21) G. Limits on oscillation time are valid for any mirror field $B'$ in (0.08–0.17) G, and for aligned fields $B$ and $B'$. For larger values of $B'$, the limits are significantly reduced.

2 Losses of neutrons due to oscillations to mirror neutrons would be maximal when the magnetic fields $B$ and $B'$ in the two worlds were equal. Hence the scan over $B$ by ALTAREV 09a: the limit applies for any $B'$ over the given range. At $B' = 0$, the limit is 141 s (95% CL).

### $n$ DECAY MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Gamma_1$</td>
<td>$p e^- \bar{\nu}_e$</td>
<td>100 %</td>
</tr>
<tr>
<td>$\Gamma_2$</td>
<td>$p e^- \bar{\nu}_e \gamma$</td>
<td>$9.2 \pm 0.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>$\Gamma_3$</td>
<td>hydrogen-atom $\bar{\nu}_e$</td>
<td>$&lt; 2.7 \times 10^{-3}$ 95%</td>
</tr>
</tbody>
</table>

**Charge conservation ($Q$) violating mode**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i/\Gamma$)</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Gamma_4$</td>
<td>$\nu \nu_e \bar{\nu}_e$</td>
<td>$&lt; 8 \times 10^{-27}$ 68%</td>
</tr>
</tbody>
</table>

[a] This limit is for $\gamma$ energies between 0.4 and 782 keV.

### $n$ BRANCHING RATIOS

#### $\Gamma(p e^- \bar{\nu}_e \gamma)/\Gamma_{\text{total}}$

<table>
<thead>
<tr>
<th>Value (units $10^{-3}$)</th>
<th>$CL%$</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$9.17 \pm 0.24 \pm 0.64$</td>
<td>1 BALES 16</td>
<td>RDK2</td>
<td>Two different set-ups</td>
<td></td>
</tr>
</tbody>
</table>

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

- BALES 16 gets a branching fraction of $(5.82 \pm 0.23 \pm 0.62) \times 10^{-3}$ for a photon energy range 0.4 to 14.0 keV, and with a different detector array, $(3.35 \pm 0.05 \pm 0.15) \times 10^{-3}$ for 14.1 to 782 keV. Our result above is the sum; the error on the sum is completely dominated by the error on the lower range.

- This COOPER 10 result is for $\gamma$ energies between 15 and 340 keV.

- This BECK 02 limit is for $\gamma$ energies between 35 and 100 keV.

#### $\Gamma(\text{hydrogen-atom } \bar{\nu}_e)/\Gamma_{\text{total}}$

| Value $<0.27 \times 10^{-2}$ | $95$ | CZARNECKI 18 | Lifeline analysis |

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

- CZARNECKI 18 limit from an analysis of experimental discrepancies on the neutron lifetime and axial coupling applies as well to other possible exotic neutron decays.

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

Baryon Decay Parameters

\[ n \to p e^{-} \nu_{e} \] \textbf{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, MOSTOVOI 96, NICO 05, SEVERIJNS 06, and ABELE 08.

\[ \lambda \equiv g_{A} / g_{V} \]

\begin{align*}
\textit{VALUE} & \quad \textit{CL\%} & \textit{DOCUMENT ID} & \textit{TECN} & \textit{COMMENT} \\
-1.2732 & \pm 0.0023 & \textbf{OUR AVERAGE} & & \\
-1.2772 & \pm 0.0020 & 1 \text{ BROWN} & 18 \text{ UCNA} & \text{Ultracold } n, \text{ polarized} \\
-1.284 & \pm 0.014 & 2 \text{ DARIUS} & 17 \text{ SPEC} & \text{Cold } n, \text{ unpolarized} \\
-1.2748 & \pm 0.0008 & 3 \text{ MUND} & 13 \text{ SPEC} & \text{Cold } n, \text{ polarized} \\
-1.275 & \pm 0.006 & 4 \text{ SCHUMANN} & 80 \text{ CNTR} & A \text{ and } B \times \text{ polarizations} \\
-1.2686 & \pm 0.0046 & 5 \text{ MOSTOVOI} & 91 \text{ UCNA} & \text{See YEROZOLIMSKII 91B} \\
-1.266 & \pm 0.004 & 6 \text{ LIAUD} & 97 \text{ TPC} & \text{Cold } n, \text{ polarized, } A \\
-1.2594 & \pm 0.0038 & 7 \text{ YEROZOLIMSKII 91B} & 113 \text{ Cd} & \text{113mSn} \text{ neutrals} \\
-1.262 & \pm 0.005 & 8 \text{ BOPP} & 97 \text{ SPEC} & \text{Cold } n, \text{ polarized, } A \\
-1.2755 & \pm 0.0030 & 9 \text{ ABELE} & 97 \text{ SPEC} & \text{Cold } n, \text{ polarized, } A \\
-1.27590 & \pm 0.00331 & 10 \text{ LIU} & 10 \text{ UCNA} & \text{See YEROZOLIMSKII 91B} \\
-1.27592 & \pm 0.00409 & 11 \text{ ABELE} & 10 \text{ UCNA} & \text{See LIU 97} \\
-1.2739 & \pm 0.0019 & 12 \text{ SCHRECK} & 97 \text{ TPC} & \text{See YEROZOLIMSKII 91B} \\
-1.274 & \pm 0.003 & 13 \text{ ABELE} & 97 \text{ SPEC} & \text{Cold } n, \text{ polarized, } A \\
-1.266 & \pm 0.004 & 14 \text{ EROZOLIMSKII 91B} & 113 \text{ Cd} & \text{113mSn} \text{ neutrals} \\
-1.2544 & \pm 0.0036 & 15 \text{ NORMAN} & 96 \text{ CNTR} & \text{See YEROZOLIMSKII 91B} \\
\end{align*}
We quote the combined values that include the earlier UCNA measurements (MENDENHALL 13).

DARIUS 17 calculates this value from the measurement of the $a$ parameter (see below).

This MUND 13 value includes earlier PERKEO II measurements (ABELE 02 and ABELE 97D).

MOSTOVOI 01 measures the two $P$-odd correlations $A$ and $B$, or rather $S_A$ and $S_B$, where $S$ is the $n$ polarization, in free neutron decay.

YEROZOLIMSKY 97 makes a correction to the EROZOLIMSKII 91 value.

MENDENHALL 13 gets $A = -0.11954 \pm 0.00055 \pm 0.00098$ and $\lambda = -1.2756 \pm 0.0030$. We quote the nearly identical values that include the earlier UCNA measurement (PLASTER 12), with a correction to that result.

This PLASTER 12 value is identical with that given in LIU 10, but the experiment is now described in detail.

This is the combined result of ABELE 02 and ABELE 97D.

These experiments measure the absolute value of $g_A/g_V$ only.

KROHN 75 includes events of CHRISTENSEN 70.

KROPF 74 reviews all data through 1972.

WEIGHTED AVERAGE
-1.2732±0.0023 (Error scaled by 2.4)
**e⁻ 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. In the Standard Model, $A$ is related to $\lambda \equiv g_A/g_V$ by $A = -2 \lambda (\lambda + 1) / (1 + 3\lambda^2)$; this assumes that $g_A$ and $g_V$ are real.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECHN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-0.1187 \pm 0.0010$ OUR AVERAGE</td>
<td>1 BROWN 18 UCNA</td>
<td>Ultracold n, polarized</td>
<td></td>
</tr>
<tr>
<td>$-0.11926 \pm 0.00031 \pm 0.00036 -0.00042$</td>
<td>2 MUND 13 SPEC</td>
<td>Cold n, polarized</td>
<td></td>
</tr>
<tr>
<td>$-0.1160 \pm 0.0009 \pm 0.0012$</td>
<td>LIAUD 97 TPC</td>
<td>Cold n, polarized</td>
<td></td>
</tr>
<tr>
<td>$-0.1135 \pm 0.0014$</td>
<td>3 YEROZLIM... 97 CNTR</td>
<td>Cold n, polarized</td>
<td></td>
</tr>
<tr>
<td>$-0.1146 \pm 0.0019$</td>
<td>BOPP 86 SPEC</td>
<td>Cold n, polarized</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECHN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-0.11952 \pm 0.00110$</td>
<td>4 MENDENHALL13 UCNA</td>
<td>See BROWN 18</td>
<td></td>
</tr>
<tr>
<td>$-0.11966 \pm 0.00089 \pm 0.00123 -0.00140$</td>
<td>5 PLASTER 12 UCNA</td>
<td>See MENDENHALL 13</td>
<td></td>
</tr>
<tr>
<td>$-0.11966 \pm 0.00089 \pm 0.00123 -0.00140$</td>
<td>LIU 10 UCNA</td>
<td>See PLASTER 12</td>
<td></td>
</tr>
<tr>
<td>$-0.1138 \pm 0.0046 \pm 0.0021$</td>
<td>PATTIE 09 SPEC</td>
<td>Ultracold n, polarized</td>
<td></td>
</tr>
<tr>
<td>$-0.1189 \pm 0.0007$</td>
<td>6 ABELE 02 SPEC</td>
<td>See MUND 13</td>
<td></td>
</tr>
<tr>
<td>$-0.1168 \pm 0.0017$</td>
<td>7 MOSTOVOI 01 CNTR</td>
<td>Inferred</td>
<td></td>
</tr>
<tr>
<td>$-0.1189 \pm 0.0012$</td>
<td>ABELE 970 SPEC</td>
<td>Cold n, polarized</td>
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<tr>
<td>$-0.1160 \pm 0.0009 \pm 0.00111$</td>
<td>SCHRECK... 95 TPC</td>
<td>See LIAUD 97</td>
<td></td>
</tr>
<tr>
<td>$-0.1116 \pm 0.0014$</td>
<td>EROZOLIM... 91 CNTR</td>
<td>See YEROZOLIM-SKY 97</td>
<td></td>
</tr>
<tr>
<td>$-0.114 \pm 0.005$</td>
<td>8 EROZOLIM... 79 CNTR</td>
<td>Cold n, polarized</td>
<td></td>
</tr>
<tr>
<td>$-0.113 \pm 0.006$</td>
<td>8 KROHN 75 CNTR</td>
<td>Cold n, polarized</td>
<td></td>
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</tbody>
</table>

**WEIGHTED AVERAGE**

$-0.1187 \pm 0.0010$ (Error scaled by 2.6)

$\chi^2$ value:

<table>
<thead>
<tr>
<th>DOCUMENT ID</th>
<th>TECHN</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BROWN 18 UCNA</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>2 MUND 13 SPEC</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>LIAUD 97 TPC</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>3 YEROZLIM... 97 CNTR</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>BOPP 86 SPEC</td>
<td>4.8</td>
<td></td>
</tr>
</tbody>
</table>

(Confidence Level < 0.0001)

**e⁻ asymmetry parameter A**
\[ \frac{\beta}{2} \text{ ASYMMETRY PARAMETER } B \]

This is the neutron-spin antineutrino-momentum correlation coefficient. In the Standard Model, \( B \) is related to \( \lambda \equiv g_A / g_V \) by \( B = 2 \lambda (\lambda - 1) / (1 + 3 \lambda^2) \); this assumes that \( g_A \) and \( g_V \) are real.

\[ \begin{array}{ccc}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
0.9807 \pm 0.0030 & \text{OUR AVERAGE} & \\
0.9802 \pm 0.0034 & \text{SCHUMANN 07} & \text{CNTR} & \text{Cold n, polarized} \\
0.967 \pm 0.006 & \text{KREUZ 05} & \text{CNTR} & \text{Cold n, polarized} \\
0.9801 \pm 0.0046 & \text{SEREBROV 98} & \text{CNTR} & \text{Cold n, polarized} \\
0.9894 \pm 0.0083 & \text{KUZNETSOV 95} & \text{CNTR} & \text{Cold n, polarized} \\
1.00 \pm 0.05 & \text{CHRISTENSEN70} & \text{CNTR} & \text{Cold n, polarized} \\
0.995 \pm 0.034 & \text{ERÖZOLIMSKY 97} & \text{CNTR} & \text{Cold n, polarized} \\
\end{array} \]

\[ \bullet \bullet \bullet \text{ We do not use the following data for averages, fits, limits, etc.} \]

\[ 0.9876 \pm 0.0004 \]

\[ 1 \text{ MOSTOVOI 01 CNTR Inferred} \]

\[ \text{1 MOSTOVOI 01 calculates this from its measurement of } \lambda = g_A / g_V \text{ above.} \]

\[ \text{PROTON ASYMMETRY PARAMETER } C \]

Describes the correlation between the neutron spin and the proton momentum. In the Standard Model, \( C \) is related to \( \lambda \equiv g_A / g_V \) by \( C = -x_a (A + B) = x_a 4\lambda/(1 + 3\lambda^2) \), where \( x_a = 0.27484 \) is a kinematic factor; this assumes that \( g_A \) and \( g_V \) are real.

\[ \begin{array}{ccc}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
-0.2377 \pm 0.0010 & \pm 0.0024 & \text{SCHUMANN 08} & \text{CNTR} & \text{Cold n, polarized} \\
\end{array} \]

\[ \text{\( e^{n_a}\) ANGULAR CORRELATION COEFFICIENT } a \]

For a review of past experiments and plans for future measurements of the \( a \) parameter, see WIETEFELDT 05. In the Standard Model, \( a \) is related to \( \lambda \equiv g_A / g_V \) by \( a = (1 - \lambda^2) / (1 + 3\lambda^2) \); this assumes that \( g_A \) and \( g_V \) are real.

\[ \begin{array}{ccc}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
-0.1059 \pm 0.0028 & \text{OUR AVERAGE} & \\
-0.1090 \pm 0.0030 & \text{DARIUS 17} & \text{SPEC} & \text{Cold n, unpolarized} \\
-0.1054 \pm 0.0055 & \text{BYRNE 02} & \text{SPEC} & \text{Proton recoil spectrum} \\
-0.1017 \pm 0.0051 & \text{STRATOWA 78} & \text{CNTR} & \text{Proton recoil spectrum} \\
-0.0911 \pm 0.0039 & \text{GRIGOREV 68} & \text{SPEC} & \text{Proton recoil spectrum} \\
\end{array} \]

\[ \bullet \bullet \bullet \text{ We do not use the following data for averages, fits, limits, etc.} \]

\[ -0.1045 \pm 0.0014 \]

\[ 2 \text{ MOSTOVOI 01 CNTR Inferred} \]

\[ \text{HTTP://PDG.LBL.GOV} \]
\( \phi_{AV} \), PHASE OF \( g_A \) RELATIVE TO \( g_V \)

Time reversal invariance requires this to be 0 or 180°. This is related to \( D \) given in the next data block and \( \lambda = g_A/g_V \) by \( \sin(\phi_{AV}) = D(1+3\lambda^2)/2|\lambda| \); this assumes that \( g_A \) and \( g_V \) are real.

\[
\begin{array}{c|c|c|c|c}
\text{VALUE (°)} & \text{CL\%} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
180.017 ± 0.026 & & OUR AVERAGE & & \\
180.012 ± 0.028 & 68 & CHUPP & 12 CNTR & Cold n, polarized > 91% \\
180.04 ± 0.09 & & SOLDNER & 04 CNTR & Cold n, polarized \\
180.08 ± 0.13 & & LISING & 00 CNTR & Polarized > 93% \\
180.013 ± 0.028 & & MUMM & 11 CNTR & See CHUPP 12 \\
179.71 ± 0.39 & & EROZOLIM... & 78 CNTR & Cold n, polarized \\
180.35 ± 0.43 & & EROZOLIM... & 74 CNTR & Cold n, polarized \\
181.1 ± 1.3 & & KROPF & 74 RVUE & \( n \) decay \\
180.14 ± 0.22 & & STEINBERG & 74 CNTR & Cold n, polarized \\
\end{array}
\]

1 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 \( \beta \) decay. Should be zero if \( T \) invariance is not violated.

\[
\begin{array}{c|c|c|c|c}
\text{VALUE (units 10^{-4})} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
−1.2 ± 2.0 & & OUR AVERAGE & & \\
−0.94 ± 1.89 ± 0.97 & & CHUPP & 12 CNTR & Cold n, polarized > 91% \\
−2.8 ± 6.4 ± 3.0 & & SOLDNER & 04 CNTR & Cold n, polarized \\
−6 ± 12 ± 5 & & LISING & 00 CNTR & Polarized > 93% \\
−0.96 ± 1.89 ± 1.01 & & MUMM & 11 CNTR & See CHUPP 12 \\
+22 ± 30 & & EROZOLIM... & 78 CNTR & Cold n, polarized \\
−27 ± 50 & & EROZOLIM... & 74 CNTR & Cold n, polarized \\
−11 ± 17 & & STEINBERG & 74 CNTR & Cold n, polarized \\
\end{array}
\]

1 EROZOLIMSKII 78 says asymmetric proton losses and nonuniform beam polarization may give a systematic error up to 30 × 10^{-4}, thus increasing the EROZOLIMSKII 74 error to 50 × 10^{-4}. STEINBERG 74 and STEINBERG 76 estimate these systematic errors to be insignificant in their experiment.

TRIPLE CORRELATION COEFFICIENT \( R \)

Another test of time-reversal invariance. \( R \) measures the polarization of the electron in the direction perpendicular to the plane defined by the neutron spin and the electron momentum. \( R = 0 \) for \( T \) invariance.

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
+0.004 ± 0.012 ± 0.005 & & \text{KOZELA} & 12 CNTR & Mott polarimeter \\
+0.008 ± 0.015 ± 0.005 & & \text{KOZELA} & 09 CNTR & See KOZELA 12 \\
\end{array}
\]

1 KOZELA 12 also measures the polarization of the electron along the direction of the neutron spin. This is nonzero in the Standard Model; the correlation coefficient is \( N = +0.067 ± 0.011 ± 0.004 \).
We have omitted some papers that have been superseded by later experiments. See our earlier editions.

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NICO 05 PPPL 55 567 M. Schumacher (GOET)
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Journal</th>
<th>Reference</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>KROPF</td>
<td>74</td>
<td>ZPHY 267 129</td>
<td>H. Kropf, E. Paul</td>
<td>(LINZ)</td>
</tr>
<tr>
<td>STEINBERG</td>
<td>74</td>
<td>PRL 33 41</td>
<td>R.I. Steinberg et al.</td>
<td>(YALE, ISNG)</td>
</tr>
<tr>
<td>STEINBERG</td>
<td>74</td>
<td>NP A154 160</td>
<td>H. Paul</td>
<td>(VIEN)</td>
</tr>
<tr>
<td>COHEN</td>
<td>73</td>
<td>JPCRD 2 664</td>
<td>E.R. Cohen, B.N. Taylor</td>
<td>(RISC, NBS)</td>
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<tr>
<td>KROHN</td>
<td>73</td>
<td>PR D8 1305</td>
<td>V.E. Krohn, G.R. Ringo</td>
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<tr>
<td>CHRISTENSEN</td>
<td>72</td>
<td>PR D5 1628</td>
<td>C.J. Christensen et al.</td>
<td>(RISO)</td>
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<tr>
<td>CHRISTENSEN</td>
<td>70</td>
<td>PR C1 1693</td>
<td>C.J. Christensen, V.E. Krohn, G.R. Ringo</td>
<td>(ANL)</td>
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<tr>
<td>EROZOLIM...</td>
<td>70</td>
<td>PL 33B 351</td>
<td>B.G. Erozolimsky et al.</td>
<td>(KIAE)</td>
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<tr>
<td>GRIGOREV</td>
<td>68</td>
<td>SJNP 6 239</td>
<td>V.K. Grigoriev et al.</td>
<td>(ITEP)</td>
</tr>
<tr>
<td>KROHN</td>
<td>66</td>
<td>PR 148 1303</td>
<td>V.E. Krohn, G.R. Ringo</td>
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<tr>
<td>LEE</td>
<td>56</td>
<td>PR 104 254</td>
<td>T.D. Lee, C.N. Yang</td>
<td>(COLU, BNL)</td>
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</table>

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