# $\Sigma^0$

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

COURANT 63 and ALFF-STEINBERGER 65, using $\Sigma^0 \to \Lambda e^+ e^-$ decays (Dalitz decays), determined the $\Sigma^0$ parity to be positive, given that $J = 1/2$ and that certain very reasonable assumptions about form factors are true. The results of experiments involving the Primakoff effect, from which the $\Sigma^0$ mean life and $\Sigma^0 \to \Lambda$ transition magnetic moment come (see below), strongly support $J = 1/2$.

## $\Sigma^0$ MASS

The fit uses $\Sigma^+$, $\Sigma^0$, $\Sigma^-$, and $\Lambda$ mass and mass-difference measurements.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **1192.642±0.024 OUR FIT** | | | | | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 1192.65 ±0.020±0.014 | 3327 | [1] WANG | 97 | SPEC | $\Sigma^0 \to \Lambda\gamma \to (p\pi^-)(e^+e^-)$ |

[1] This WANG 97 result is redundant with the $\Sigma^0$-$\Lambda$ mass-difference measurement below.

### $m_{\Sigma^-} - m_{\Sigma^0}$

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **4.807±0.035 OUR FIT** | Error includes scale factor of 1.1. | | | | |
| **4.86 ±0.08 OUR AVERAGE** | Error includes scale factor of 1.2. | | | | |
| 4.87 ±0.12 | 37 | DOSCH | 65 | HBC | |
| 5.01 ±0.12 | 12 | SCHMIDT | 65 | HBC | See note with $\Lambda$ mass |
| 4.75 ±0.1 | 18 | BURNSTEIN | 64 | HBC | |

### $m_{\Sigma^0} - m_{\Lambda}$

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **76.959±0.023 OUR FIT** | | | | | |
| **76.966±0.020±0.013** | 3327 | WANG | 97 | SPEC | $\Sigma^0 \to \Lambda\gamma \to (p\pi^-)(e^+e^-)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 76.23 ±0.55 | 109 | COLAS | 75 | HLBC | $\Sigma^0 \to \Lambda\gamma$ |
| 76.63 ±0.28 | 208 | SCHMIDT | 65 | HBC | See note with $\Lambda$ mass |

## $\Sigma^0$ MEAN LIFE

These lifetimes are deduced from measurements of the cross sections for the Primakoff process $\Lambda \rightarrow \Sigma^0$ in nuclear Coulomb fields. An alternative expression of the same information is the $\Sigma^0$-$\Lambda$ transition magnetic moment given in the following section. The relation is $(\mu_{\Sigma\Lambda}/\mu_N)^2\ \tau = 1.92951 \times 10^{-19}$ s (see DEVLIN 86).

| VALUE ($10^{-20}$ s) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **7.4±0.7 OUR EVALUATION** | Using $\mu_{\Sigma\Lambda}$ (see the above note). | | | |
| $6.5^{+1.7}_{-1.1}$ | [2] DEVLIN | 86 | SPEC | Primakoff effect |
| $7.6 \pm 0.5 \pm 0.7$ | [3] PETERSEN | 86 | SPEC | Primakoff effect |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $5.8 \pm 1.3$ | [2] DYDAK | 77 | SPEC | See DEVLIN 86 |

[2] DEVLIN 86 is a recalculation of the results of DYDAK 77 removing a numerical approximation made in that work.
[3] An additional uncertainty of the Primakoff formalism is estimated to be $< 5\%$.

## $|\mu(\Sigma^0 \rightarrow \Lambda)|$ TRANSITION MAGNETIC MOMENT

See the note in the $\Sigma^0$ mean-life section above. Also, see the "Note on Baryon Magnetic Moments" in the $\Lambda$ Listings.

| VALUE ($\mu_N$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1.61±0.08 OUR AVERAGE** | | | | |
| $1.72^{+0.17}_{-0.19}$ | [4] DEVLIN | 86 | SPEC | Primakoff effect |
| $1.59 \pm 0.05 \pm 0.07$ | [5] PETERSEN | 86 | SPEC | Primakoff effect |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $1.82^{+0.25}_{-0.18}$ | [4] DYDAK | 77 | SPEC | See DEVLIN 86 |

[4] DEVLIN 86 is a recalculation of the results of DYDAK 77 removing a numerical approximation made in that work.
[5] An additional uncertainty of the Primakoff formalism is estimated to be $< 2.5\%$.

## $\Sigma^0$ DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) | Confidence level |
|---|---|---|---|
| $\Gamma_1$ | $\Lambda\gamma$ | 100 % | |
| $\Gamma_2$ | $\Lambda\gamma\gamma$ | $< 3\ \%$ | 90% |
| $\Gamma_3$ | $\Lambda e^+ e^-$ | [a] $5 \times 10^{-3}$ | |

[a] A theoretical value using QED.

## $\Sigma^0$ BRANCHING RATIOS

### $\Gamma(\Lambda\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$

| VALUE | CL% | DOCUMENT ID | | TECN |
|---|---|---|---|---|
| **<0.03** | 90 | COLAS | 75 | HLBC |

## $\Gamma(\Lambda e^+ e^-)/\Gamma_{total}$ $\Gamma_3/\Gamma$

See COURANT 63 and ALFF-STEINBERGER 65 for measurements of the invariant-mass spectrum of the Dalitz pairs.

| *VALUE* | *DOCUMENT ID* | | *COMMENT* |
|---|---|---|---|
| **0.00545** | FEINBERG | 58 | Theoretical QED calculation |

## $\Sigma^0$ REFERENCES


| | | | | |
|---|---|---|---|---|
| WANG | 97 | PR D56 2544 | M.H.L.S. Wang *et al.* | (BNL-E766 Collab.) |
| DEVLIN | 86 | PR D34 1626 | T. Devlin, P.C. Petersen, A. Beretvas | (RUTG) |
| PETERSEN | 86 | PRL 57 949 | P.C. Petersen *et al.* | (RUTG, WISC, MICH+) |
| DYDAK | 77 | NP B118 1 | F. Dydak *et al.* | (CERN, DORT, HEIDH) |
| COLAS | 75 | NP B91 253 | J. Colas *et al.* | (ORSAY) |
| ALFF-... | 65 | PR 137B 1105 | C. Alff-Steinberger *et al.* | (COLU, RUTG+) P |
| DOSCH | 65 | PL 14 239 | H.C. Dosch *et al.* | (HEID) |
| SCHMIDT | 65 | PR 140B 1328 | P. Schmidt | (COLU) |
| BURNSTEIN | 64 | PRL 13 66 | R.A. Burnstein *et al.* | (UMD) |
| COURANT | 63 | PRL 10 409 | H. Courant *et al.* | (CERN, UMD) P |
| FEINBERG | 58 | PR 109 1019 | G. Feinberg | (BNL) |