# $\Lambda(1405)$ $1/2^-$

$I(J^P) = 0(\frac{1}{2}^-)$ Status: ∗∗∗∗

In the 1998 Note on the $\Lambda(1405)$ in PDG 98, R.H. Dalitz discussed the S-shaped cusp behavior of the intensity at the $N$-$\overline{K}$ threshold observed in THOMAS 73 and HEMINGWAY 85. He commented that this behavior "is characteristic of $S$-wave coupling; the other below threshold hyperon, the $\Sigma(1385)$, has no such threshold distortion because its $N$-$\overline{K}$ coupling is $P$-wave. For $\Lambda(1405)$ this asymmetry is the sole direct evidence that $J^P = 1/2^-$."

A recent measurement by the CLAS collaboration, MORIYA 14, definitively established the long-assumed $J^P = 1/2^-$ spin-parity assignment of the $\Lambda(1405)$. The experiment produced the $\Lambda(1405)$ spin-polarized in the photoproduction process $\gamma p \rightarrow K^+ \Lambda(1405)$ and measured the decay of the $\Lambda(1405)$(polarized) $\rightarrow \Sigma^+$(polarized)$\pi^-$. The observed isotropic decay of $\Lambda(1405)$ is consistent with spin $J = 1/2$. The polarization transfer to the $\Sigma^+$(polarized) direction revealed negative parity, and thus established $J^P = 1/2^-$.

## See the related review(s):

Pole Structure of the $\Lambda(1405)$ Region

## $\Lambda(1405)$ POLE POSITION

### REAL PART

| VALUE (MeV) | DOCUMENT ID | | TECN |
|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| $1417.7^{+6.0+1.1}_{-7.4-1.0}$ | AIKAWA | 23 | DPWA |
| $1429^{+8}_{-7}$ | [1] MAI | 15 | DPWA |
| $1434 \pm 2$ | [2] MAI | 15 | DPWA |
| $1421^{+3}_{-2}$ | GUO | 13 | DPWA |
| $1424^{+7}_{-23}$ | IKEDA | 12 | DPWA |

[1] Solution number 4.
[2] Solution number 2.

### −2×IMAGINARY PART

| VALUE (MeV) | DOCUMENT ID | | TECN |
|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| $52.2^{+12.0+3.4}_{-15.8-4.0}$ | AIKAWA | 23 | DPWA |
| $24^{+4}_{-6}$ | [1] MAI | 15 | DPWA |
| $20^{+4}_{-2}$ | [2] MAI | 15 | DPWA |

| | | | |
|---|---|---|---|
| 38 $^{+16}_{-10}$ | GUO | 13 | DPWA |
| 52 $^{+\ 6}_{-28}$ | IKEDA | 12 | DPWA |

[1] Solution number 4.
[2] Solution number 2.

## $\Lambda(1405)$ MASS

### PRODUCTION EXPERIMENTS

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$1405.1^{+\ 1.3}_{-\ 1.0}$ OUR AVERAGE** | | | | | |
| $1405\ ^{+11}_{-\ 9}$ | | HASSANVAND | 13 | SPEC | $p p \to p \Lambda(1405) K^+$ |
| $1405\ ^{+\ 1.4}_{-\ 1.0}$ | | ESMAILI | 10 | RVUE | $^4$He $K^- \to \Sigma^\pm \pi^\mp X$ at rest |
| $1406.5 \pm 4.0$ | | [1] DALITZ | 91 | | M-matrix fit |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $1391 \pm 1$ | 700 | [1] HEMINGWAY | 85 | HBC | $K^- p$ 4.2 GeV/$c$ |
| $\sim 1405$ | 400 | [2] THOMAS | 73 | HBC | $\pi^- p$ 1.69 GeV/$c$ |
| 1405 | 120 | BARBARO-... | 68B | DBC | $K^- d$ 2.1–2.7 GeV/$c$ |
| $1400 \pm 5$ | 67 | BIRMINGHAM | 66 | HBC | $K^- p$ 3.5 GeV/$c$ |
| $1382 \pm 8$ | | ENGLER | 65 | HDBC | $\pi^- p$, $\pi^+ d$ 1.68 GeV/$c$ |
| $1400 \pm 24$ | | MUSGRAVE | 65 | HBC | $\overline{p} p$ 3–4 GeV/$c$ |
| 1410 | | ALEXANDER | 62 | HBC | $\pi^- p$ 2.1 GeV/$c$ |
| 1405 | | ALSTON | 62 | HBC | $K^- p$ 1.2–0.5 GeV/$c$ |
| 1405 | | ALSTON | 61B | HBC | $K^- p$ 1.15 GeV/$c$ |

[1] DALITZ 91 fits the HEMINGWAY 85 data.
[2] THOMAS 73 data is fit by CHAO 73 (see next section).

### EXTRAPOLATIONS BELOW $N\overline{K}$ THRESHOLD

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 1407.56 or 1407.50 | [1] KIMURA | 00 | | potential model |
| 1411 | [2] MARTIN | 81 | | K-matrix fit |
| 1406 | [3] CHAO | 73 | DPWA | 0–range fit (sol. B) |
| 1421 | MARTIN | 70 | RVUE | Constant K-matrix |
| $1416 \pm 4$ | MARTIN | 69 | HBC | Constant K-matrix |
| $1403 \pm 3$ | KIM | 67 | HBC | K-matrix fit |
| $1407.5 \pm 1.2$ | [4] KITTEL | 66 | HBC | 0–effective-range fit |
| $1410.7 \pm 1.0$ | KIM | 65 | HBC | 0–effective-range fit |
| $1409.6 \pm 1.7$ | [4] SAKITT | 65 | HBC | 0–effective-range fit |

[1] The KIMURA 00 values are from fits A and B from a coupled-channel potential model using low-energy $\overline{K} N$ and $\Sigma \pi$ data, kaonic-hydrogen x-ray measurements, and our $\Lambda(1405)$ mass and width. The results bear mainly on the *nature* of the $\Lambda(1405)$: three-quark state or $\overline{K} N$ bound state.
[2] The MARTIN 81 fit includes the $K^\pm p$ forward scattering amplitudes and the dispersion relations they must satisfy.
[3] See also the accompanying paper of THOMAS 73.
[4] Data of SAKITT 65 are used in the fit by KITTEL 66.

# $\Lambda(1405)$ WIDTH

## PRODUCTION EXPERIMENTS

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **50.5± 2.0 OUR AVERAGE** | | | | | |
| 62 ±10 | | HASSANVAND | 13 | SPEC | $p p \to p \Lambda(1405) K^+$ |
| 50 ± 2 | | [1] DALITZ | 91 | | M-matrix fit |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 24 $^{+4}_{-3}$ | | ESMAILI | 10 | RVUE | $^4$He $K^- \to \Sigma^\pm \pi^\mp X$ at rest |
| 32 ± 1 | 700 | [1] HEMINGWAY | 85 | HBC | $K^- p$ 4.2 GeV/$c$ |
| 45 to 55 | 400 | [2] THOMAS | 73 | HBC | $\pi^- p$ 1.69 GeV/$c$ |
| 35 | 120 | BARBARO-... | 68B | DBC | $K^- d$ 2.1–2.7 GeV/$c$ |
| 50 ±10 | 67 | BIRMINGHAM | 66 | HBC | $K^- p$ 3.5 GeV/$c$ |
| 89 ±20 | | ENGLER | 65 | HDBC | |
| 60 ±20 | | MUSGRAVE | 65 | HBC | |
| 35 ± 5 | | ALEXANDER | 62 | HBC | |
| 50 | | ALSTON | 62 | HBC | |
| 20 | | ALSTON | 61B | HBC | |

[1] DALITZ 91 fits the HEMINGWAY 85 data.
[2] THOMAS 73 data is fit by CHAO 73 (see next section).

## EXTRAPOLATIONS BELOW $N\overline{K}$ THRESHOLD

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 50.24 or 50.26 | [1] KIMURA | 00 | | potential model |
| 30 | [2] MARTIN | 81 | | K-matrix fit |
| 55 | [3,4] CHAO | 73 | DPWA | 0–range fit (sol. B) |
| 20 | MARTIN | 70 | RVUE | Constant K-matrix |
| 29 ±6 | MARTIN | 69 | HBC | Constant K-matrix |
| 50 ±5 | KIM | 67 | HBC | K-matrix fit |
| 34.1±4.1 | [5] KITTEL | 66 | HBC | |
| 37.0±3.2 | KIM | 65 | HBC | |
| 28.2±4.1 | [5] SAKITT | 65 | HBC | |

[1] The KIMURA 00 values are from fits A and B from a coupled-channel potential model using low-energy $\overline{K} N$ and $\Sigma \pi$ data, kaonic-hydrogen x-ray measurements, and our $\Lambda(1405)$ mass and width. The results bear mainly on the *nature* of the $\Lambda(1405)$: three-quark state or $\overline{K} N$ bound state.
[2] The MARTIN 81 fit includes the $K^\pm p$ forward scattering amplitudes and the dispersion relations they must satisfy.
[3] An asymmetric shape, with $\Gamma/2 = 41$ MeV below resonance, 14 MeV above.
[4] See also the accompanying paper of THOMAS 73.
[5] Data of SAKITT 65 are used in the fit by KITTEL 66.

# $\Lambda(1405)$ DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $\Sigma \pi$ | 100 % |
| $\Gamma_2$ | $\Lambda \gamma$ | |
| $\Gamma_3$ | $\Sigma^0 \gamma$ | |
| $\Gamma_4$ | $N \overline{K}$ | |

## $\Lambda(1405)$ PARTIAL WIDTHS

### $\Gamma(\Lambda\gamma)$ $\Gamma_2$

| VALUE (keV) | DOCUMENT ID | COMMENT |
|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | |
| $27\pm8$ | BURKHARDT 91 | Isobar model fit |

### $\Gamma(\Sigma^0\gamma)$ $\Gamma_3$

| VALUE (keV) | DOCUMENT ID | COMMENT |
|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | |
| $10\pm4$ or $23\pm7$ | BURKHARDT 91 | Isobar model fit |

## $\Lambda(1405)$ BRANCHING RATIOS

### $\Gamma(N\overline{K})/\Gamma(\Sigma\pi)$ $\Gamma_4/\Gamma_1$

| VALUE | CL% | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $<3$ | 95 | HEMINGWAY 85 | HBC | $K^- p$ 4.2 GeV/$c$ |

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