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

$I(J^P) = 0(\frac{1}{2}^-)$ 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)π^-. The observed isotropic decay of $\Lambda(1405)$ is consistent with spin $J = 1/2$. The polarization transfer to the Σ^+(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. • • •			
1429^{+8}_{-7}	[1] MAI	15	DPWA
1434 ± 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.

$-2\times$IMAGINARY PART

VALUE (MeV)	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
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 ± 4.0		[1] DALITZ	91		M-matrix fit
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1391 ± 1	700	[1] HEMINGWAY	85	HBC	$K^- p$ 4.2 GeV/c
~ 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 ± 5	67	BIRMINGHAM	66	HBC	$K^- p$ 3.5 GeV/c
1382 ± 8		ENGLER	65	HDBC	$\pi^- p$, $\pi^+ d$ 1.68 GeV/c
1400 ± 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 ± 4	MARTIN	69	HBC	Constant K-matrix
1403 ± 3	KIM	67	HBC	K-matrix fit
1407.5 ± 1.2	[4] KITTEL	66	HBC	0–effective-range fit
1410.7 ± 1.0	KIM	65	HBC	0–effective-range fit
1409.6 ± 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 $K^- \rightarrow \Sigma^\pm \pi^\mp X$ at rest
$32\ \pm\ 1$	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
$50\ \pm 10$	67	BIRMINGHAM	66	HBC	$K^- p$ 3.5 GeV/c
$89\ \pm 20$		ENGLER	65	HDBC	
$60\ \pm 20$		MUSGRAVE	65	HBC	
$35\ \pm\ 5$		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
$29\ \pm 6$	MARTIN	69	HBC	Constant K-matrix
$50\ \pm 5$	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 (Γ_i/Γ)
Γ_1	$\Sigma \pi$	100 %
Γ_2	$\Lambda \gamma$	
Γ_3	$\Sigma^0 \gamma$	
Γ_4	$N \overline{K}$	

$\Lambda(1405)$ PARTIAL WIDTHS

$\Gamma(\Lambda\gamma)$ Γ_2

VALUE (keV)	DOCUMENT ID		COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
27 ± 8	BURKHARDT	91	Isobar model fit

$\Gamma(\Sigma^0\gamma)$ Γ_3

VALUE (keV)	DOCUMENT ID	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •		
10 ± 4 or 23 ± 7	BURKHARDT 91	Isobar model fit

Λ(1405) BRANCHING RATIOS

$\Gamma(N\overline{K})/\Gamma(\Sigma\pi)$ Γ_4/Γ_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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