

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

$I(J^P) = 0(\frac{1}{2}^-)$ 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 $N\text{-}\bar{K}$ 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 $N\text{-}\bar{K}$ 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) $\rightarrow \Sigma^+(\text{polarized})\pi^-$. The observed isotropic decay of $\Lambda(1405)$ is consistent with spin $J = 1/2$. The polarization transfer to the $\Sigma^+(\text{polarized})$ 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 ± 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	$pp \rightarrow p\Lambda(1405)K^+$
1405 ^{+1.4} _{-1.0}		ESMAILI 10	RVUE	$^4\text{He } K^- \rightarrow \Sigma^\pm \pi^\mp X \text{ at rest}$
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	$\bar{p} p$ 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 $N\bar{K}$ 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	$pp \rightarrow p\Lambda(1405)K^+$
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	$^4\text{He } K^- \rightarrow \Sigma^\pm \pi^\mp X$ 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 $\overline{N\overline{K}}$ 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 (Γ_i/Γ)
$\Gamma_1 \quad \Sigma \pi$	100 %
$\Gamma_2 \quad \Lambda \gamma$	
$\Gamma_3 \quad \Sigma^0 \gamma$	
$\Gamma_4 \quad N \bar{K}$	

$\Lambda(1405)$ 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	

$\Lambda(1405)$ BRANCHING RATIOS

$\Gamma(N \bar{K})/\Gamma(\Sigma \pi)$					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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KIMURA	00	PR C62 015206	M. Kimura <i>et al.</i>	
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CHAO	73	NP B56 46	Y.A. Chao <i>et al.</i>	(RHEL, CMU, LOUC)
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