

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

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

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 $N\bar{K}$ 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 $N\bar{K}$ 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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
● ● ● 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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
$52.2^{+12}_{-15.8} \ +3.4_{-4.0}$	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
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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	$^4\text{He } K^- \rightarrow \Sigma^\pm \pi^\mp X$ 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 $\bar{p} p$ 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 $\bar{N}K$ THRESHOLD

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
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● ● ● 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 $\bar{K}N$ 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 $\bar{K}N$ 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	

¹DALITZ 91 fits the HEMINGWAY 85 data.

²THOMAS 73 data is fit by CHAO 73 (see next section).

EXTRAPOLATIONS BELOW \overline{NK} 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	00	potential model
30	² MARTIN 81	81	K-matrix fit
55	^{3,4} CHAO 73	DPWA 73	0-range fit (sol. B)
20	MARTIN 70	RVUE 70	Constant K-matrix
29 ± 6	MARTIN 69	HBC 69	Constant K-matrix
50 ± 5	KIM 67	HBC 67	K-matrix fit
34.1 ± 4.1	⁵ KITTEL 66	HBC 66	
37.0 ± 3.2	KIM 65	HBC 65	
28.2 ± 4.1	⁵ SAKITT 65	HBC 65	

¹The 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.

²The MARTIN 81 fit includes the $K^\pm p$ forward scattering amplitudes and the dispersion relations they must satisfy.

³An asymmetric shape, with $\Gamma/2 = 41$ MeV below resonance, 14 MeV above.

⁴See also the accompanying paper of THOMAS 73.

⁵Data 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

$\Lambda(1405)$ 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

$\Lambda(1405)$ REFERENCES

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IKEDA	12	NP A881 98	Y. Ikeda, T. Hyodo, W. Weise	(TUM, RIKEN, TINT)
ESMAILI	10	PL B686 23	J. Esmaili, Y. Akaishi, T. Yamazaki	(RIKEN, ISUT+)
KIMURA	00	PR C62 015206	M. Kimura <i>et al.</i>	
PDG	98	EPJ C3 1	C. Caso <i>et al.</i>	(PDG Collab.)
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DALITZ	91	JP G17 289	R.H. Dalitz, A. Deloff	(OXFTP, WINR)
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MARTIN	81	NP B179 33	A.D. Martin	(DURH)
CHAO	73	NP B56 46	Y.A. Chao <i>et al.</i>	(RHEL, CMU, LOUC)
THOMAS	73	NP B56 15	D.W. Thomas <i>et al.</i>	(CMU) J
MARTIN	70	NP B16 479	A.D. Martin, G.G. Ross	(DURH)
MARTIN	69	PR 183 1352	B.R. Martin, M. Sakitt	(LOUC, BNL)
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BARBARO-...	68B	PRL 21 573	A. Barbaro-Galtieri <i>et al.</i>	(LRL, SLAC)
KIM	67	PRL 19 1074	J.K. Kim	(YALE)
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