

$\Lambda(1405) \ 1/2^-$ $I(J^P) = 0(\frac{1}{2}^-)$ 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 $N\bar{K}$ 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 ⁺ ₋ $\begin{matrix} 6.0+1.1 \\ 7.4-1.0 \end{matrix}$	AIKAWA	23 DPWA
1429 $\begin{matrix} + 8 \\ - 7 \end{matrix}$	¹ MAI	15 DPWA
1434 ± 2	² MAI	15 DPWA
1421 $\begin{matrix} + 3 \\ - 2 \end{matrix}$	GUO	13 DPWA
1424 $\begin{matrix} + 7 \\ - 23 \end{matrix}$	IKEDA	12 DPWA

¹Solution number 4.

²Solution 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 ⁺ ₋ $\begin{matrix} 12.0+3.4 \\ 15.8-4.0 \end{matrix}$	AIKAWA	23 DPWA
24 $\begin{matrix} + 4 \\ - 6 \end{matrix}$	¹ MAI	15 DPWA
20 $\begin{matrix} + 4 \\ - 2 \end{matrix}$	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{KN} 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{KN} 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 **$\Gamma(N\bar{K})/\Gamma(\Sigma\pi)$** **$\Gamma_4/\Gamma_1$**

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

 $\Lambda(1405)$ REFERENCES

AIKAWA	23	PL B837 137637	S. Aikawa <i>et al.</i>	(J-PARC E31 Collab.)
MAI	15	EPJ A51 30	M. Mai, U.-G. Meissner	(BONN, JULI)
MORIYA	14	PRL 112 082004	K. Moriya <i>et al.</i>	(CLAS Collab.) JP
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HASSANVAND	13	PR C87 055202	M. Hassanvand <i>et al.</i>	
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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.)
BURKHARDT	91	PR C44 607	H. Burkhardt, J. Lowe	(NOTT, UNM, BIRM)
DALITZ	91	JP G17 289	R.H. Dalitz, A. Deloff	(OXFTP, WINR)
HEMINGWAY	85	NP B253 742	R.J. Hemingway	(CERN) J
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)
Also		PR 183 1345	B.R. Martin, M. Sakitt	(LOUC, BNL)
BARBARO-...	68B	PRL 21 573	A. Barbaro-Galtieri <i>et al.</i>	(LRL, SLAC)
KIM	67	PRL 19 1074	J.K. Kim	(YALE)
BIRMINGHAM	66	PR 152 1148	M. Haque <i>et al.</i>	(BIRM, GLAS, LOIC, OXF+)
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