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

$I(J^P) = 0(\frac{1}{2}^{-})$ 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	$pp \to p\Lambda(1405)K^+$
$1405\ ^{+1.4}_{-1.0}$		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	$pp \to p\Lambda(1405)K^+$
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 (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

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

$\Lambda(1405)$ REFERENCES

MAI	15	EPJ A51 30	M. Mai, U.-G. Meissner	(BONN, JULI)	
MORIYA	14	PRL 112 082004	K. Moriya *et al.*	(CLAS Collab.)	JP
GUO	13	PR C87 035202	Z.-H. Guo, J. Oller		
HASSANVAND	13	PR C87 055202	M. Hassanvand *et al.*		
Also		PR C88 019905 (errat.)	M. Hassanvand *et al.*		
IKEDA	12	NP A881 98	Y. Ikeda, T. Hyodo, W. Weise	(MUNT, RIKEN, TINT)	
ESMAILI	10	PL B686 23	J. Esmaili, Y. Akaishi, T. Yamazaki	(RIKEN, ISUT+)	
KIMURA	00	PR C62 015206	M. Kimura *et al.*		
PDG	98	EPJ C3 1	C. Caso *et al.*	(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 *et al.*	(RHEL, CMU, LOUC)	
THOMAS	73	NP B56 15	D.W. Thomas *et al.*	(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 *et al.*	(LRL, SLAC)	
KIM	67	PRL 19 1074	J.K. Kim	(YALE)	
BIRMINGHAM	66	PR 152 1148	M. Haque *et al.*	(BIRM, GLAS, LOIC, OXF+)	
KITTEL	66	PL 21 349	W. Kittel, G. Otter, I. Wacek	(VIEN)	
ENGLER	65	PRL 15 224	A. Engler *et al.*	(CMU, BNL)	IJ
KIM	65	PRL 14 29	J.K. Kim	(COLU)	
MUSGRAVE	65	NC 35 735	B. Musgrave *et al.*	(BIRM, CERN, EPOL+)	
SAKITT	65	PR 139 B719	M. Sakitt *et al.*	(UMD, LRL)	
ALEXANDER	62	PRL 8 447	G. Alexander *et al.*	(LRL)	I
ALSTON	62	CERN Conf. 311	M.H. Alston *et al.*	(LRL)	I
ALSTON	61B	PRL 6 698	M.H. Alston *et al.*	(LRL)	I

OTHER RELATED PAPERS

IWASAKI	97	PRL 78 3067	M. Iwasaki *et al.*	(KEK 228 Collab.)
FINK	90	PR C41 2720	P.J.Jr. Fink *et al.*	(IBMY, ORST, ANSM)
LEINWEBER	90	ANP 198 203	D.B. Leinweber	(MCMS)
MUELLER-GR...	90	NP A513 557	A. Mueller-Groeling, K. Holinde, J. Speth	(JULI)
BARRETT	89	NC 102A 179	R.C. Barrett	(SURR)
BATTY	89	NC 102A 255	C.J. Batty, A. Gal	(RAL, HEBR)
CAPSTICK	89	Excited Baryons 88, p.32	S. Capstick	(GUEL)
LOWE	89	NC 102A 167	J. Lowe	(BIRM)
WHITEHOUSE	89	PRL 63 1352	D.A. Whitehouse *et al.*	(BIRM, BOST, BRCO+)
SIEGEL	88	PR C38 2221	P.B. Siegel, W. Weise	(REGE)
WORKMAN	88	PR D37 3117	R.L. Workman, H.W. Fearing	(TRIU)
SCHNICK	87	PRL 58 1719	J. Schnick, R.H. Landau	(ORST)
CAPSTICK	86	PR D34 2809	S. Capstick, N. Isgur	(TNTO)
JENNINGS	86	PL B176 229	B.K. Jennings	(TRIU)
MALTMAN	86	PR D34 1372	K. Maltman, N. Isgur	(LANL, TNTO)
ZHONG	86	PL B171 471	Y.S. Zhong *et al.*	(ADLD, TRIU, SURR)
BURKHARDT	85	NP A440 653	H. Burkhardt, J. Lowe, A.S. Rosenthal	(NOTT+)
DAREWYCH	85	PR D32 1765	J.W. Darewych, R. Koniuk, N. Isgur	(YORKC, TNTO)
VEIT	85	PR D31 1033	E.A. Veit *et al.*	(TRIU, ADLD, SURR)
KIANG	84	PR C30 1638	D. Kiang *et al.*	(DALH, MCMS)
MILLER	84	Conference paper	D.J. Miller	(LOUC)
Conf. Intersections between Particle and Nuclear Physics, p. 783				
VANDIJK	84	PR D30 937	W. van Dijk	(MCMS)
VEIT	84	PL 137B 415	E.A. Veit *et al.*	(TRIU, SURR, CERN)
DALITZ	82	Heid. Conf.	R.H. Dalitz *et al.*	(OXFTP)
Heidelberg Conf., p. 201				
DALITZ	81	Kaon Conf.	R.H. Dalitz, J.G. McGinley	(OXFTP)
Low and Intermediate Energy Kaon-Nucleon Physics, p.381				
MARTIN	81B	Kaon Conf.	A.D. Martin	(DURH)
Low and Intermediate Energy Kaon-Nucelon Physics, p. 97				
OADES	77	NC 42A 462	G.C. Oades, G. Rasche	(AARH, ZURI)
SHAW	73	Purdue Conf. 417	G.L. Shaw	(UCI)
BARBARO-...	72	LBL-555	A. Barbaro-Galtieri	(LBL)
DOBSON	72	PR D6 3256	P.N. Dobson, R. McElhaney	(HAWA)
RAJASEKA...	72	PR D5 610	G. Rajasekaran	(TATA)
Earlier papers also cited in RAJASEKARAN 72.				
CLINE	71	PRL 26 1194	D. Cline, R. Laumann, J. Mapp	(WISC)
MARTIN	71	PL 35B 62	A.D. Martin, A.D. Martin, G.G. Ross	(DURH, LOUC+)
DALITZ	67	PR 153 1617	R.H. Dalitz, T.C. Wong, G. Rajasekaran	(OXFTP+)
DONALD	66	PL 22 711	R.A. Donald *et al.*	(LIVP)
KADYK	66	PRL 17 599	J.A. Kadyk *et al.*	(LRL)
ABRAMS	65	PR 139 B454	G.S. Abrams, B. Sechi-Zorn	(UMD)