

$\Lambda(1405) 1/2^-$  $I(J^P) = 0(\frac{1}{2}^-)$  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. • • •		
$1429^{+8}_{-7}$	<sup>1</sup> MAI	15 DPWA
$1434 \pm 2$	<sup>2</sup> MAI	15 DPWA
$1421^{+3}_{-2}$	GUO	13 DPWA
$1424^{+7}_{-23}$	IKEDA	12 DPWA

<sup>1</sup> Solution number 4.

<sup>2</sup> Solution number 2.

#### -2xIMAGINARY PART

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •		
$24^{+4}_{-6}$	<sup>1</sup> MAI	15 DPWA
$20^{+4}_{-2}$	<sup>2</sup> MAI	15 DPWA
$38^{+16}_{-10}$	GUO	13 DPWA
$52^{+6}_{-28}$	IKEDA	12 DPWA

<sup>1</sup>Solution number 4.<sup>2</sup>Solution number 2.

## $\Lambda(1405)$ MASS

### PRODUCTION EXPERIMENTS

VALUE (MeV)	EVTs	DOCUMENT ID	TECN	COMMENT
<b>1405.1<sup>+1.3</sup><sub>-1.0</sub></b>		<b>OUR AVERAGE</b>		
1405 <sup>+11</sup> <sub>-9</sub>		HASSANVAND 13	SPEC	$pp \rightarrow p\Lambda(1405)K^+$
1405 <sup>+1.4</sup> <sub>-1.0</sub>		ESMAILI 10	RVUE	$^4\text{He } K^- \rightarrow \Sigma^\pm \pi^\mp X$ at rest
1406.5 $\pm$ 4.0		<sup>1</sup> DALITZ 91		M-matrix fit
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1391 $\pm$ 1	700	<sup>1</sup> HEMINGWAY 85	HBC	$K^- p$ 4.2 GeV/ $c$
~ 1405	400	<sup>2</sup> 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/ $c$

<sup>1</sup>DALITZ 91 fits the HEMINGWAY 85 data.<sup>2</sup>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	<sup>1</sup> KIMURA 00		potential model
1411	<sup>2</sup> MARTIN 81		K-matrix fit
1406	<sup>3</sup> 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	<sup>4</sup> KITTEL 66	HBC	0–effective-range fit
1410.7 $\pm$ 1.0	KIM 65	HBC	0–effective-range fit
1409.6 $\pm$ 1.7	<sup>4</sup> SAKITT 65	HBC	0–effective-range fit

<sup>1</sup>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.<sup>2</sup>The MARTIN 81 fit includes the  $K^\pm p$  forward scattering amplitudes and the dispersion relations they must satisfy.<sup>3</sup>See also the accompanying paper of THOMAS 73.<sup>4</sup>Data of SAKITT 65 are used in the fit by KITTEL 66.

## $\Lambda(1405)$ WIDTH

### PRODUCTION EXPERIMENTS

VALUE (MeV)	EPTS	DOCUMENT ID	TECN	COMMENT
<b>50.5 ± 2.0 OUR AVERAGE</b>				
62 ± 10		HASSANVAND 13	SPEC	$pp \rightarrow p\Lambda(1405)K^+$
50 ± 2		<sup>1</sup> 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	<sup>1</sup> HEMINGWAY 85	HBC	$K^- p$ 4.2 GeV/c
45 to 55	400	<sup>2</sup> 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	

<sup>1</sup>DALITZ 91 fits the HEMINGWAY 85 data.

<sup>2</sup>THOMAS 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	<sup>1</sup> KIMURA 00	00	potential model
30	<sup>2</sup> MARTIN 81	81	K-matrix fit
55	<sup>3,4</sup> CHAO 73	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	<sup>5</sup> KITTEL 66	HBC	
37.0 ± 3.2	KIM 65	HBC	
28.2 ± 4.1	<sup>5</sup> SAKITT 65	HBC	

<sup>1</sup>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.

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

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

<sup>4</sup>See also the accompanying paper of THOMAS 73.

<sup>5</sup>Data of SAKITT 65 are used in the fit by KITTEL 66.

### $\Lambda(1405)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $\Sigma\pi$	100 %
$\Gamma_2$ $\Lambda\gamma$	
$\Gamma_3$ $\Sigma^0\gamma$	
$\Gamma_4$ $N\overline{K}$	

**$\Lambda(1405)$  PARTIAL WIDTHS** **$\Gamma(\Lambda\gamma)$   $\Gamma_2$** 

VALUE (keV)	DOCUMENT ID	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

27 ± 8	BURKHARDT 91	Isobar model fit
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 **$\Gamma(\Sigma^0\gamma)$   $\Gamma_3$** 

VALUE (keV)	DOCUMENT ID	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

10 ± 4 or 23 ± 7	BURKHARDT 91	Isobar model fit
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 **$\Lambda(1405)$  BRANCHING RATIOS** **$\Gamma(N\bar{K})/\Gamma(\Sigma\pi)$   $\Gamma_4/\Gamma_1$** 

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$<3$	95	HEMINGWAY 85	HBC	K <sup>-</sup> p 4.2 GeV/c
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 **$\Lambda(1405)$  REFERENCES**

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