

CHARMED, STRANGE MESONS ($C = S = \pm 1$)

$$D_s^+ = c\bar{s}, D_s^- = \bar{c}s, \quad \text{similarly for } D_s^{*'}\text{'s}$$

D_s^\pm

$$I(J^P) = 0(0^-)$$

$$\text{Mass } m = 1968.30 \pm 0.11 \text{ MeV} \quad (S = 1.1)$$

$$m_{D_s^\pm} - m_{D^\pm} = 98.69 \pm 0.05 \text{ MeV}$$

$$\text{Mean life } \tau = (500 \pm 7) \times 10^{-15} \text{ s} \quad (S = 1.3)$$

$$c\tau = 149.9 \mu\text{m}$$

CP-violating decay-rate asymmetries

$$A_{CP}(\mu^\pm \nu) = (5 \pm 6)\%$$

$$A_{CP}(K^\pm K_S^0) = (0.08 \pm 0.26)\%$$

$$A_{CP}(K^+ K^- \pi^\pm) = (-0.5 \pm 0.9)\%$$

$$A_{CP}(K^\pm K_S^0 \pi^0) = (-2 \pm 6)\%$$

$$A_{CP}(2K_S^0 \pi^\pm) = (3 \pm 5)\%$$

$$A_{CP}(K^+ K^- \pi^\pm \pi^0) = (0.0 \pm 3.0)\%$$

$$A_{CP}(K^\pm K_S^0 \pi^+ \pi^-) = (-6 \pm 5)\%$$

$$A_{CP}(K_S^0 K^\mp 2\pi^\pm) = (4.1 \pm 2.8)\%$$

$$A_{CP}(\pi^+ \pi^- \pi^\pm) = (-0.7 \pm 3.1)\%$$

$$A_{CP}(\pi^\pm \eta) = (1.1 \pm 3.1)\%$$

$$A_{CP}(\pi^\pm \eta') = (-2.2 \pm 2.3)\%$$

$$A_{CP}(\eta \pi^\pm \pi^0) = (-1 \pm 4)\%$$

$$A_{CP}(\eta' \pi^\pm \pi^0) = (0 \pm 8)\%$$

$$A_{CP}(K^\pm \pi^0) = (-27 \pm 24)\%$$

$$A_{CP}(K_S^0 \pi^\pm) = (1.2 \pm 1.0)\% \quad (S = 1.3)$$

$$A_{CP}(K^\pm \pi^+ \pi^-) = (4 \pm 5)\%$$

$$A_{CP}(K^\pm \eta) = (9 \pm 15)\%$$

$$A_{CP}(K^\pm \eta'(958)) = (6 \pm 19)\%$$

T-violating decay-rate asymmetry

$$A_T(K_S^0 K^\pm \pi^+ \pi^-) = (-14 \pm 8) \times 10^{-3} \text{ [a]}$$

$D_s^+ \rightarrow \phi \ell^+ \nu_\ell$ form factors

$$r_2 = 0.84 \pm 0.11 \quad (S = 2.4)$$

$$r_\nu = 1.80 \pm 0.08$$

$$\Gamma_L/\Gamma_T = 0.72 \pm 0.18$$

Unless otherwise noted, the branching fractions for modes with a resonance in the final state include all the decay modes of the resonance. D_S^- modes are charge conjugates of the modes below.

D_S^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	ρ (MeV/c)
Inclusive modes			
e^+ semileptonic	[b] (6.5 \pm 0.4) %		—
π^+ anything	(119.3 \pm 1.4) %		—
π^- anything	(43.2 \pm 0.9) %		—
π^0 anything	(123 \pm 7) %		—
K^- anything	(18.7 \pm 0.5) %		—
K^+ anything	(28.9 \pm 0.7) %		—
K_S^0 anything	(19.0 \pm 1.1) %		—
η anything	[c] (29.9 \pm 2.8) %		—
ω anything	(6.1 \pm 1.4) %		—
η' anything	[d] (11.7 \pm 1.8) %		—
$f_0(980)$ anything, $f_0 \rightarrow \pi^+ \pi^-$	< 1.3 %	CL=90%	—
ϕ anything	(15.7 \pm 1.0) %		—
$K^+ K^-$ anything	(15.8 \pm 0.7) %		—
$K_S^0 K^+$ anything	(5.8 \pm 0.5) %		—
$K_S^0 K^-$ anything	(1.9 \pm 0.4) %		—
$2K_S^0$ anything	(1.70 \pm 0.32) %		—
$2K^+$ anything	< 2.6 $\times 10^{-3}$	CL=90%	—
$2K^-$ anything	< 6 $\times 10^{-4}$	CL=90%	—
Leptonic and semileptonic modes			
$e^+ \nu_e$	< 8.3 $\times 10^{-5}$	CL=90%	984
$\mu^+ \nu_\mu$	(5.56 \pm 0.25) $\times 10^{-3}$		981
$\tau^+ \nu_\tau$	(5.54 \pm 0.24) %		182
$K^+ K^- e^+ \nu_e$	—		851
$\phi e^+ \nu_e$	[e] (2.49 \pm 0.14) %		720
$\eta e^+ \nu_e + \eta'(958) e^+ \nu_e$	[e] (3.66 \pm 0.37) %		—
$\eta e^+ \nu_e$	[e] (2.67 \pm 0.29) %	S=1.1	908
$\eta'(958) e^+ \nu_e$	[e] (9.9 \pm 2.3) $\times 10^{-3}$		751
$\omega e^+ \nu_e$	[f] < 2.0 $\times 10^{-3}$	CL=90%	829
$K^0 e^+ \nu_e$	(3.7 \pm 1.0) $\times 10^{-3}$		921
$K^*(892)^0 e^+ \nu_e$	[e] (1.8 \pm 0.7) $\times 10^{-3}$		782
$f_0(980) e^+ \nu_e, f_0 \rightarrow \pi^+ \pi^-$	(2.00 \pm 0.32) $\times 10^{-3}$		—

Hadronic modes with a $K\bar{K}$ pair

$K^+ K_S^0$	(1.49±0.06) %		850
$K^+ \bar{K}^0$	(2.95±0.14) %		850
$K^+ K^- \pi^+$	[g] (5.39±0.21) %	S=1.4	805
$\phi \pi^+$	[e,h] (4.5 ±0.4) %		712
$\phi \pi^+, \phi \rightarrow K^+ K^-$	[h] (2.24±0.10) %		712
$K^+ \bar{K}^*(892)^0, \bar{K}^{*0} \rightarrow K^- \pi^+$	(2.58±0.11) %		416
$f_0(980) \pi^+, f_0 \rightarrow K^+ K^-$	(1.14±0.31) %		732
$f_0(1370) \pi^+, f_0 \rightarrow K^+ K^-$	(7 ±5) × 10 ⁻⁴		—
$f_0(1710) \pi^+, f_0 \rightarrow K^+ K^-$	(6.6 ±2.9) × 10 ⁻⁴		198
$K^+ \bar{K}_0^*(1430)^0, \bar{K}_0^* \rightarrow K^- \pi^+$	(1.8 ±0.4) × 10 ⁻³		218
$K^+ K_S^0 \pi^0$	(1.52±0.22) %		805
$2K_S^0 \pi^+$	(7.7 ±0.6) × 10 ⁻³		802
$K^0 \bar{K}^0 \pi^+$	—		802
$K^*(892)^+ \bar{K}^0$	[e] (5.4 ±1.2) %		683
$K^+ K^- \pi^+ \pi^0$	(6.3 ±0.7) %	S=1.1	748
$\phi \rho^+$	[e] (8.4 ^{+1.9} / _{-2.3}) %		401
$K_S^0 K^- 2\pi^+$	(1.66±0.11) %		744
$K^*(892)^+ \bar{K}^*(892)^0$	[e] (7.2 ±2.6) %		417
$K^+ K_S^0 \pi^+ \pi^-$	(1.03±0.10) %		744
$K^+ K^- 2\pi^+ \pi^-$	(8.6 ±1.5) × 10 ⁻³		673
$\phi 2\pi^+ \pi^-$	[e] (1.21±0.16) %		640
$K^+ K^- \rho^0 \pi^+ \text{non-}\phi$	< 2.6 × 10 ⁻⁴	CL=90%	249
$\phi \rho^0 \pi^+, \phi \rightarrow K^+ K^-$	(6.5 ±1.3) × 10 ⁻³		181
$\phi a_1(1260)^+, \phi \rightarrow K^+ K^-, a_1^+ \rightarrow \rho^0 \pi^+$	(7.4 ±1.2) × 10 ⁻³		†
$K^+ K^- 2\pi^+ \pi^- \text{nonresonant}$	(9 ±7) × 10 ⁻⁴		673
$2K_S^0 2\pi^+ \pi^-$	(8 ±4) × 10 ⁻⁴		669

Hadronic modes without K 's

$\pi^+ \pi^0$	< 3.4 × 10 ⁻⁴	CL=90%	975
$2\pi^+ \pi^-$	(1.09±0.05) %	S=1.2	959
$\rho^0 \pi^+$	(2.0 ±1.2) × 10 ⁻⁴		825
$\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$	[i] (9.0 ±0.5) × 10 ⁻³		959
$f_2(1270) \pi^+, f_2 \rightarrow \pi^+ \pi^-$	(1.09±0.20) × 10 ⁻³		559
$\rho(1450)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$	(3.0 ±1.9) × 10 ⁻⁴		421
$\pi^+ 2\pi^0$	(6.5 ±1.3) × 10 ⁻³		960
$2\pi^+ \pi^- \pi^0$	—		935
$\eta \pi^+$	[e] (1.69±0.10) %	S=1.2	902
$\omega \pi^+$	[e] (2.4 ±0.6) × 10 ⁻³		822
$3\pi^+ 2\pi^-$	(7.9 ±0.8) × 10 ⁻³		899

$2\pi^+\pi^-2\pi^0$	—	902
$\eta\rho^+$	[e] (8.9 ± 0.8) %	724
$\eta\pi^+\pi^0$	(9.2 ± 1.2) %	885
$\omega\pi^+\pi^0$	[e] (2.8 ± 0.7) %	802
$3\pi^+2\pi^-\pi^0$	(4.9 ± 3.2) %	856
$\omega2\pi^+\pi^-$	[e] (1.6 ± 0.5) %	766
$\eta'(958)\pi^+$	[d,e] (3.94 ± 0.25) %	743
$3\pi^+2\pi^-2\pi^0$	—	803
$\omega\eta\pi^+$	[e] < 2.13 %	CL=90% 654
$\eta'(958)\rho^+$	[d,e] (12.5 ± 2.2) %	465
$\eta'(958)\pi^+\pi^0$	(5.6 ± 0.8) %	720

Modes with one or three K's

$K^+\pi^0$	(6.3 ± 2.1) × 10 ⁻⁴	917
$K_S^0\pi^+$	(1.21 ± 0.06) × 10 ⁻³	916
$K^+\eta$	[e] (1.76 ± 0.35) × 10 ⁻³	835
$K^+\omega$	[e] < 2.4 × 10 ⁻³	CL=90% 741
$K^+\eta'(958)$	[e] (1.8 ± 0.6) × 10 ⁻³	646
$K^+\pi^+\pi^-$	(6.5 ± 0.4) × 10 ⁻³	900
$K^+\rho^0$	(2.5 ± 0.4) × 10 ⁻³	745
$K^+\rho(1450)^0, \rho^0 \rightarrow \pi^+\pi^-$	(6.9 ± 2.4) × 10 ⁻⁴	—
$K^*(892)^0\pi^+, K^{*0} \rightarrow$	(1.41 ± 0.24) × 10 ⁻³	775
$K^+\pi^-$		
$K^*(1410)^0\pi^+, K^{*0} \rightarrow$	(1.23 ± 0.28) × 10 ⁻³	—
$K^+\pi^-$		
$K^*(1430)^0\pi^+, K^{*0} \rightarrow$	(5.0 ± 3.5) × 10 ⁻⁴	—
$K^+\pi^-$		
$K^+\pi^+\pi^-$ nonresonant	(1.04 ± 0.34) × 10 ⁻³	900
$K^0\pi^+\pi^0$	(1.00 ± 0.18) %	899
$K_S^02\pi^+\pi^-$	(3.0 ± 1.1) × 10 ⁻³	870
$K^+\omega\pi^0$	[e] < 8.2 × 10 ⁻³	CL=90% 684
$K^+\omega\pi^+\pi^-$	[e] < 5.4 × 10 ⁻³	CL=90% 603
$K^+\omega\eta$	[e] < 7.9 × 10 ⁻³	CL=90% 366
$2K^+K^-$	(2.16 ± 0.21) × 10 ⁻⁴	627
$\phi K^+, \phi \rightarrow K^+K^-$	(8.8 ± 2.0) × 10 ⁻⁵	—

Doubly Cabibbo-suppressed modes

$2K^+\pi^-$	(1.26 ± 0.13) × 10 ⁻⁴	805
$K^+K^*(892)^0, K^{*0} \rightarrow$	(5.9 ± 3.4) × 10 ⁻⁵	—
$K^+\pi^-$		

Baryon-antibaryon mode

$p\bar{n}$	(1.3 ± 0.4) × 10 ⁻³	295
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**$\Delta C = 1$ weak neutral current (C1) modes,
Lepton family number (LF), or
Lepton number (L) violating modes**

$\pi^+ e^+ e^-$		$[j] < 1.3$	$\times 10^{-5}$	CL=90%	979
$\pi^+ \phi, \phi \rightarrow e^+ e^-$		$[k] (6 \begin{smallmatrix} +8 \\ -4 \end{smallmatrix}) \times 10^{-6}$			—
$\pi^+ \mu^+ \mu^-$		$[j] < 4.1$	$\times 10^{-7}$	CL=90%	968
$K^+ e^+ e^-$	C1	< 3.7	$\times 10^{-6}$	CL=90%	922
$K^+ \mu^+ \mu^-$	C1	< 2.1	$\times 10^{-5}$	CL=90%	909
$K^*(892)^+ \mu^+ \mu^-$	C1	< 1.4	$\times 10^{-3}$	CL=90%	765
$\pi^+ e^+ \mu^-$	LF	< 1.2	$\times 10^{-5}$	CL=90%	976
$\pi^+ e^- \mu^+$	LF	< 2.0	$\times 10^{-5}$	CL=90%	976
$K^+ e^+ \mu^-$	LF	< 1.4	$\times 10^{-5}$	CL=90%	919
$K^+ e^- \mu^+$	LF	< 9.7	$\times 10^{-6}$	CL=90%	919
$\pi^- 2e^+$	L	< 4.1	$\times 10^{-6}$	CL=90%	979
$\pi^- 2\mu^+$	L	< 1.2	$\times 10^{-7}$	CL=90%	968
$\pi^- e^+ \mu^+$	L	< 8.4	$\times 10^{-6}$	CL=90%	976
$K^- 2e^+$	L	< 5.2	$\times 10^{-6}$	CL=90%	922
$K^- 2\mu^+$	L	< 1.3	$\times 10^{-5}$	CL=90%	909
$K^- e^+ \mu^+$	L	< 6.1	$\times 10^{-6}$	CL=90%	919
$K^*(892)^- 2\mu^+$	L	< 1.4	$\times 10^{-3}$	CL=90%	765

$D_s^{*\pm}$

$$I(J^P) = 0(??)$$

J^P is natural, width and decay modes consistent with 1^- .

Mass $m = 2112.1 \pm 0.4$ MeV

$m_{D_s^{*\pm}} - m_{D_s^\pm} = 143.8 \pm 0.4$ MeV

Full width $\Gamma < 1.9$ MeV, CL = 90%

D_s^{*-} modes are charge conjugates of the modes below.

D_s^{*+} DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D_s^+ \gamma$	(94.2±0.7) %	139
$D_s^+ \pi^0$	(5.8±0.7) %	48

$D_{s0}^*(2317)^\pm$

$$I(J^P) = 0(0^+)$$

J, P need confirmation.

J^P is natural, low mass consistent with 0^+ .

Mass $m = 2317.7 \pm 0.6$ MeV ($S = 1.1$)

$m_{D_{s0}^*(2317)^\pm} - m_{D_s^\pm} = 349.4 \pm 0.6$ MeV ($S = 1.1$)

Full width $\Gamma < 3.8$ MeV, CL = 95%

$D_{s0}^*(2317)^-$ modes are charge conjugates of modes below.

$D_{s0}^*(2317)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D_s^+ \pi^0$	seen	298
$D_s^+ \pi^0 \pi^0$	not seen	205

$D_{s1}(2460)^\pm$

$$I(J^P) = 0(1^+)$$

Mass $m = 2459.5 \pm 0.6$ MeV ($S = 1.1$)

$m_{D_{s1}(2460)^\pm} - m_{D_s^{*\pm}} = 347.3 \pm 0.7$ MeV ($S = 1.2$)

$m_{D_{s1}(2460)^\pm} - m_{D_s^\pm} = 491.2 \pm 0.6$ MeV ($S = 1.1$)

Full width $\Gamma < 3.5$ MeV, CL = 95%

$D_{s1}(2460)^-$ modes are charge conjugates of the modes below.

$D_{s1}(2460)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$D_s^{*+} \pi^0$	(48 ± 11) %		297
$D_s^+ \gamma$	(18 ± 4) %		442
$D_s^+ \pi^+ \pi^-$	(4.3 ± 1.3) %	S=1.1	363
$D_s^{*+} \gamma$	< 8 %	CL=90%	323
$D_{s0}^*(2317)^+ \gamma$	(3.7 ^{+5.0} _{-2.4}) %		138

$D_{s1}(2536)^\pm$

$$I(J^P) = 0(1^+)$$

J, P need confirmation.

Mass $m = 2535.10 \pm 0.08$ MeV ($S = 1.1$)

Full width $\Gamma = 0.92 \pm 0.05$ MeV

$D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

$D_{s1}(2536)^\pm$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$D^*(2010)^+ K^0$	0.85 ± 0.12		149
$(D^*(2010)^+ K^0)_{S-wave}$	0.61 ± 0.09		149
$D^+ \pi^- K^+$	0.028 ± 0.005		176
$D^*(2007)^0 K^+$	DEFINED AS 1		167
$D^+ K^0$	< 0.34	90%	381
$D^0 K^+$	< 0.12	90%	391
$D_s^{*+} \gamma$	possibly seen		388
$D_s^+ \pi^+ \pi^-$	seen		437

$D_{s2}^*(2573)$

$$I(J^P) = 0(?^?)$$

J^P is natural, width and decay modes consistent with 2^+ .

Mass $m = 2571.9 \pm 0.8$ MeV

Full width $\Gamma = 17 \pm 4$ MeV ($S = 1.3$)

$D_{s2}^*(2573)^-$ modes are charge conjugates of the modes below.

$D_{s2}^*(2573)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0 K^+$	seen	434
$D^*(2007)^0 K^+$	not seen	243

$D_{s1}^*(2700)^\pm$

$$I(J^P) = 0(1^-)$$

Mass $m = 2709 \pm 4$ MeV

Full width $\Gamma = 117 \pm 13$ MeV

NOTES

- [a] See the Particle Listings for the (complicated) definition of this quantity.
- [b] This is the purely e^+ semileptonic branching fraction: the e^+ fraction from τ^+ decays has been subtracted off. The sum of our (non- τ) e^+ exclusive fractions — an $e^+ \nu_e$ with an η , η' , ϕ , K^0 , K^{*0} , or $f_0(980)$ — is 7.0 ± 0.4 %
- [c] This fraction includes η from η' decays.
- [d] Two times (to include μ decays) the $\eta' e^+ \nu_e$ branching fraction, plus the $\eta' \pi^+$, $\eta' \rho^+$, and $\eta' K^+$ fractions, is $(18.6 \pm 2.3)\%$, which considerably exceeds the inclusive η' fraction of $(11.7 \pm 1.8)\%$. Our best guess is that the $\eta' \rho^+$ fraction, $(12.5 \pm 2.2)\%$, is too large.
- [e] This branching fraction includes all the decay modes of the final-state resonance.
- [f] A test for $u\bar{u}$ or $d\bar{d}$ content in the D_s^+ . Neither Cabibbo-favored nor Cabibbo-suppressed decays can contribute, and ω - ϕ mixing is an unlikely explanation for any fraction above about 2×10^{-4} .
- [g] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.
- [h] We decouple the $D_s^+ \rightarrow \phi \pi^+$ branching fraction obtained from mass projections (and used to get some of the other branching fractions) from

the $D_s^+ \rightarrow \phi \pi^+$, $\phi \rightarrow K^+ K^-$ branching fraction obtained from the Dalitz-plot analysis of $D_s^+ \rightarrow K^+ K^- \pi^+$. That is, the ratio of these two branching fractions is not exactly the $\phi \rightarrow K^+ K^-$ branching fraction 0.491.

- [i] This is the average of a model-independent and a K -matrix parametrization of the $\pi^+ \pi^-$ S -wave and is a sum over several f_0 mesons.
- [j] This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.
- [k] This is *not* a test for the $\Delta C=1$ weak neutral current, but leads to the $\pi^+ \ell^+ \ell^-$ final state.