

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

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

D_s^\pm

$$\Gamma(J^P) = 0(0^-)$$

Mass $m = 1968.34 \pm 0.07$ MeV

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

$$\text{Mean life } \tau = (504 \pm 4) \times 10^{-15} \text{ s} \quad (S = 1.2)$$

$$c\tau = 151.2 \mu\text{m}$$

\mathcal{CP} -violating decay-rate asymmetries

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

$$A_{CP}(K^\pm K_S^0) = (0.09 \pm 0.26)\%$$

$$A_{CP}(K^\pm K_L^0) \text{ in } D_s^\pm \rightarrow K^\pm K_L^0 = (-1.1 \pm 2.7) \times 10^{-2}$$

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

$$A_{CP}(\phi\pi^\pm) = (-0.38 \pm 0.27)\%$$

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

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

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

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

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

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

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

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

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

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

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

$$A_{CP}(\bar{K}^0 / K^0 \pi^\pm) = (0.4 \pm 0.5)\%$$

$$A_{CP}(K_S^0 \pi^\pm) = (0.20 \pm 0.18)\%$$

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

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

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

\mathcal{CP} violating asymmetries of P -odd (T -odd) moments

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

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

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

$$r_v = 1.80 \pm 0.08$$

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

$$f_+(0) |V_{cs}| \text{ in } D_s^+ \rightarrow \eta e^+ \nu_e = 0.446 \pm 0.007$$

$$f_+(0) |V_{cs}| \text{ in } D_s^+ \rightarrow \eta' e^+ \nu_e = 0.48 \pm 0.05$$

 CP violating asymmetries of P -odd (T -odd) moments

$$f_+(0) |V_{cd}| \text{ in } D_s^+ \rightarrow K^0 e^+ \nu_e = 0.162 \pm 0.019$$

$$r_v \equiv V(0)/A_1(0) \text{ in } D_s^+ \rightarrow K^*(892)^0 e^+ \nu_e = 1.7 \pm 0.4$$

$$r_2 \equiv A_2(0)/A_1(0) \text{ in } D_s^+ \rightarrow K^*(892)^0 e^+ \nu_e = 0.77 \pm 0.29$$

$$f_{D_s^+} |V_{cs}| \text{ in } D_s^+ \rightarrow \mu^+ \nu_\mu = 246 \pm 5 \text{ MeV}$$

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	(MeV/c) <i>p</i>
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] (10.3 \pm 1.4) %	S=1.1	—
$f_0(980)$ 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	
$\mu^+ \nu_\mu$	(	5.49 ± 0.16	$\times 10^{-3}$		981
$\tau^+ \nu_\tau$	(	5.48 ± 0.23	%		182
$\gamma e^+ \nu_e$	<	1.3	$\times 10^{-4}$	CL=90%	984	
$K^+ K^- e^+ \nu_e$			—		851	
$\phi e^+ \nu_e$	[e]	(	2.39 ± 0.16	%	720
$\phi \mu^+ \nu_\mu$		(	1.9 ± 0.5	) %	715
$\eta e^+ \nu_e + \eta'(958) e^+ \nu_e$	[e]	(	3.03 ± 0.24	%	—
$\eta e^+ \nu_e$	[e]	(	2.32 ± 0.08	%	908
$\eta'(958) e^+ \nu_e$	[e]	(	8.0 ± 0.7	$\times 10^{-3}$	751
$\eta \mu^+ \nu_\mu$		(	2.4 ± 0.5	) %	905
$\eta'(958) \mu^+ \nu_\mu$		(	1.1 ± 0.5	) %	747
$\omega e^+ \nu_e$	[f]	<	2.0	$\times 10^{-3}$	CL=90%	829
$K^0 e^+ \nu_e$		(3.4 ± 0.4	$\times 10^{-3}$		921
$K^*(892)^0 e^+ \nu_e$	[e]	(2.15 ± 0.28	$\times 10^{-3}$	S=1.1	782

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

$K^+ K_S^0$		(	1.46 ± 0.04	%	S=1.1	850
$K^+ K_L^0$		(	1.49 ± 0.06	%		850
$K^+ \overline{K}^0$		(	2.95 ± 0.14	%		850
$K^+ K^- \pi^+$	[g]	(	5.39 ± 0.15	%	S=1.2	805
$\phi \pi^+$	[e,h]	(	4.5 ± 0.4	) %		712
$\phi \pi^+, \phi \rightarrow K^+ K^-$	[h]	(	2.24 ± 0.08	%		712
$K^+ \overline{K}^*(892)^0, \overline{K}^{*0} \rightarrow K^- \pi^+$		(	2.58 ± 0.08	%		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	$\times 10^{-4}$		—
$f_0(1710) \pi^+, f_0 \rightarrow K^+ K^-$		(	6.6 ± 2.8	$\times 10^{-4}$		198
$K^+ \overline{K}_0^*(1430)^0, \overline{K}_0^* \rightarrow K^- \pi^+$		(	1.8 ± 0.4	$\times 10^{-3}$		218
$K^+ K_S^0 \pi^0$		(	1.52 ± 0.22	%		805
$2K_S^0 \pi^+$		(	7.7 ± 0.6	$\times 10^{-3}$		802
$K^0 \overline{K}^0 \pi^+$		—				802
$K^*(892)^+ \overline{K}^0$	[e]	(	5.4 ± 1.2	) %		683
$K^+ K^- \pi^+ \pi^0$		(	6.2 ± 0.6	) %	S=1.1	748
$\phi \rho^+$	[e]	(	$8.4^{+1.9}_{-2.3}$	) %		401
$K_S^0 K^- 2\pi^+$		(	1.65 ± 0.10	%		744
$K^*(892)^+ \overline{K}^*(892)^0$	[e]	(	7.2 ± 2.6	) %		417
$K^+ K_S^0 \pi^+ \pi^-$		(	9.9 ± 0.8	$\times 10^{-3}$		744
$K^+ K^- 2\pi^+ \pi^-$		(	8.6 ± 1.5	$\times 10^{-3}$		673
$\phi 2\pi^+ \pi^-$	[e]	(	1.21 ± 0.16	%		640
$\phi \rho^0 \pi^+, \phi \rightarrow K^+ K^-$		(	6.5 ± 1.3	$\times 10^{-3}$		181

$\phi a_1(1260)^+$, $\phi \rightarrow K^+ K^-$, $a_1^+ \rightarrow \rho^0 \pi^+$	(7.4 \pm 1.2) $\times 10^{-3}$	—	†
$\phi 2\pi^+\pi^-$ non- ρ , $\phi \rightarrow K^+ K^-$	(1.8 \pm 0.7) $\times 10^{-3}$	—	—
$K^+ K^- \rho^0 \pi^+$ non- ϕ	< 2.6 $\times 10^{-4}$	CL=90%	249
$K^+ K^- 2\pi^+\pi^-$ nonresonant	(9 \pm 7) $\times 10^{-4}$	—	673
$2K_S^0 2\pi^+\pi^-$	(8.4 \pm 3.5) $\times 10^{-4}$	—	669
Hadronic modes without K's			
$\pi^+\pi^0$	< 3.4 $\times 10^{-4}$	CL=90%	975
$2\pi^+\pi^-$	(1.08 \pm 0.04) %	S=1.1	959
$\rho^0 \pi^+$	(1.9 \pm 1.2) $\times 10^{-4}$	—	825
$\pi^+(\pi^+\pi^-)_{S\text{-wave}}$	[i] (9.0 \pm 0.4) $\times 10^{-3}$	—	959
$f_2(1270)\pi^+$, $f_2 \rightarrow \pi^+\pi^-$	(1.09 \pm 0.20) $\times 10^{-3}$	—	559
$\rho(1450)^0 \pi^+$, $\rho^0 \rightarrow \pi^+\pi^-$	(3.0 \pm 1.9) $\times 10^{-4}$	—	421
$\pi^+ 2\pi^0$	(6.5 \pm 1.3) $\times 10^{-3}$	—	961
$2\pi^+\pi^-\pi^0$	—	—	935
$\eta\pi^+$	[e] (1.68 \pm 0.10) %	S=1.2	902
$\omega\pi^+$	[e] (1.92 \pm 0.30) $\times 10^{-3}$	—	822
$3\pi^+ 2\pi^-$	(7.9 \pm 0.8) $\times 10^{-3}$	—	899
$2\pi^+\pi^- 2\pi^0$	—	—	902
$\eta\rho^+$	[e] (8.9 \pm 0.8) %	—	724
$\eta\pi^+\pi^0$	(9.5 \pm 0.5) %	—	885
$\eta(\pi^+\pi^0)_{P\text{-wave}}$	(5.1 \pm 3.1) $\times 10^{-3}$	—	885
$a_0(980)^{+0} \pi^{0+}$,	(2.2 \pm 0.4) %	—	—
$a_0(980)^{+0} \rightarrow \eta\pi^{+0}$	—	—	—
$\omega\pi^+\pi^0$	[e] (2.8 \pm 0.7) %	—	802
$3\pi^+ 2\pi^- \pi^0$	(4.9 \pm 3.2) %	—	856
$\omega 2\pi^+\pi^-$	[e] (1.6 \pm 0.5) %	—	766
$\eta'(958)\pi^+$	[d,e] (3.94 \pm 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] (5.8 \pm 1.5) %	—	465
$\eta'(958)\pi^+\pi^0$	(5.6 \pm 0.8) %	—	720
$\eta'(958)\pi^+\pi^0$ nonresonant	< 5.1 %	CL=90%	720
Modes with one or three K's			
$K^+\pi^0$	(6.1 \pm 2.1) $\times 10^{-4}$	—	917
$K_S^0 \pi^+$	(1.19 \pm 0.05) $\times 10^{-3}$	—	916
$K^+\eta$	[e] (1.72 \pm 0.34) $\times 10^{-3}$	—	835
$K^+\omega$	[e] (8.7 \pm 2.5) $\times 10^{-4}$	—	741
$K^+\eta'(958)$	[e] (1.7 \pm 0.5) $\times 10^{-3}$	—	646
$K^+\pi^+\pi^-$	(6.5 \pm 0.4) $\times 10^{-3}$	—	900
$K^+\rho^0$	(2.5 \pm 0.4) $\times 10^{-3}$	—	745

$K^+ \rho(1450)^0$, $\rho^0 \rightarrow \pi^+ \pi^-$	(6.9 ± 2.4) $\times 10^{-4}$	-	
$K^*(892)^0 \pi^+$, $K^{*0} \rightarrow K^+ \pi^-$	(1.41 ± 0.24) $\times 10^{-3}$	775	
$K^*(1410)^0 \pi^+$, $K^{*0} \rightarrow K^+ \pi^-$	(1.23 ± 0.28) $\times 10^{-3}$	-	
$K^*(1430)^0 \pi^+$, $K^{*0} \rightarrow K^+ \pi^-$	(5.0 ± 3.5) $\times 10^{-4}$	-	
$K^+ \pi^+ \pi^-$ nonresonant	(1.03 ± 0.34) $\times 10^{-3}$	900	
$K^0 \pi^+ \pi^0$	(1.00 ± 0.18) %	899	
$K_S^0 2\pi^+ \pi^-$	(3.0 ± 1.1) $\times 10^{-3}$	870	
$K^+ \omega \pi^0$	[e] < 8.2 $\times 10^{-3}$	CL=90%	684
$K^+ \omega \pi^+ \pi^-$	[e] < 5.4 $\times 10^{-3}$	CL=90%	603
$K^+ \omega \eta$	[e] < 7.9 $\times 10^{-3}$	CL=90%	366
$2K^+ K^-$	(2.16 ± 0.20) $\times 10^{-4}$	628	
$\phi K^+, \phi \rightarrow K^+ K^-$	(8.8 ± 2.0) $\times 10^{-5}$	-	

Doubly Cabibbo-suppressed modes

$2K^+ \pi^-$	(1.28 ± 0.04) $\times 10^{-4}$	805
$K^+ K^*(892)^0, K^{*0} \rightarrow K^+ \pi^-$	(6.0 ± 3.4) $\times 10^{-5}$	-

Baryon-antibaryon mode

$p\bar{n}$	(1.22 ± 0.11) $\times 10^{-3}$	295	
$p\bar{p} e^+ \nu_e$	< 2.0 $\times 10^{-4}$	CL=90%	296

$\Delta C = 1$ 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 ± 8) $\times 10^{-6}$	-	
$\pi^+ \mu^+ \mu^-$	[j] < 4.1 $\times 10^{-7}$	CL=90%	968
$K^+ e^+ e^-$	<i>C1</i> < 3.7 $\times 10^{-6}$	CL=90%	922
$K^+ \mu^+ \mu^-$	<i>C1</i> < 2.1 $\times 10^{-5}$	CL=90%	909
$K^*(892)^+ \mu^+ \mu^-$	<i>C1</i> < 1.4 $\times 10^{-3}$	CL=90%	765
$\pi^+ e^+ \mu^-$	<i>LF</i> < 1.2 $\times 10^{-5}$	CL=90%	976
$\pi^+ e^- \mu^+$	<i>LF</i> < 2.0 $\times 10^{-5}$	CL=90%	976
$K^+ e^+ \mu^-$	<i>LF</i> < 1.4 $\times 10^{-5}$	CL=90%	919
$K^+ e^- \mu^+$	<i>LF</i> < 9.7 $\times 10^{-6}$	CL=90%	919
$\pi^- 2e^+$	<i>L</i> < 4.1 $\times 10^{-6}$	CL=90%	979
$\pi^- 2\mu^+$	<i>L</i> < 1.2 $\times 10^{-7}$	CL=90%	968
$\pi^- e^+ \mu^+$	<i>L</i> < 8.4 $\times 10^{-6}$	CL=90%	976
$K^- 2e^+$	<i>L</i> < 5.2 $\times 10^{-6}$	CL=90%	922
$K^- 2\mu^+$	<i>L</i> < 1.3 $\times 10^{-5}$	CL=90%	909
$K^- e^+ \mu^+$	<i>L</i> < 6.1 $\times 10^{-6}$	CL=90%	919
$K^*(892)^- 2\mu^+$	<i>L</i> < 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 $m = 2112.2 \pm 0.4$ 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)
$D_s^+ \gamma$	(93.5 \pm 0.7) %	139
$D_s^+ \pi^0$	(5.8 \pm 0.7) %	48
$D_s^+ e^+ e^-$	(6.7 \pm 1.6) $\times 10^{-3}$	139

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

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

 J, P need confirmation. J^P is natural, low mass consistent with 0^+ .Mass $m = 2317.8 \pm 0.5$ MeV

$m_{D_{s0}^*(2317)^\pm} - m_{D_s^\pm} = 349.4 \pm 0.5$ MeV

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)	Confidence level	p (MeV/c)
$D_s^+ \pi^0$	(100 \pm 0) %		298
$D_s^+ \gamma$	< 5 %	90%	323
$D_s^*(2112)^+ \gamma$	< 6 %	90%	—
$D_s^+ \gamma\gamma$	< 18 %	95%	323
$D_s^*(2112)^+ \pi^0$	< 11 %	90%	—
$D_s^+ \pi^+ \pi^-$	< 4 $\times 10^{-3}$	90%	194
$D_s^+ \pi^0 \pi^0$	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.

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

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

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

J, P need confirmation.

Mass $m = 2535.11 \pm 0.06$ MeV

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

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

$D_{s1}(2536)^+$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$D^*(2010)^+ K^0$	0.85 \pm 0.12		149
$(D^*(2010)^+ K^0)_{S-wave}$	0.61 \pm 0.09		149
$D^+ \pi^- K^+$	0.028 \pm 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

$D_{s2}^*(2573)$

$$I(J^P) = 0(2^+)$$

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

Mass $m = 2569.1 \pm 0.8$ MeV ($S = 2.4$)

Full width $\Gamma = 16.9 \pm 0.7$ MeV

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

$D_{s2}^*(2573)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0 K^+$	seen	431
$D^*(2007)^0 K^+$	not seen	238

$D_{s1}^*(2700)^\pm$ $J(J^P) = 0(1^-)$ Mass $m = 2708.3^{+4.0}_{-3.4}$ MeVFull width $\Gamma = 120 \pm 11$ 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 , or K^{*0} — is 5.99 ± 0.31 %.
- [c] This fraction includes η from η' decays.
- [d] The sum of our exclusive η' fractions — $\eta' e^+ \nu_e$, $\eta' \mu^+ \nu_\mu$, $\eta' \pi^+$, $\eta' \rho^+$, and $\eta' K^+$ — is 11.8 ± 1.6 %.
- [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 $\omega-\phi$ 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.