STRANGE MESONS
($S = \pm 1$, $C = B = 0$)

$K^+ = u\overline{s}$, $K^0 = d\overline{s}$, $\overline{K}^0 = \overline{d}s$, $K^- = \overline{u}s$, similarly for K^*'s

$K^\pm$

$$I(J^P) = \tfrac{1}{2}(0^-)$$

Mass $m = 493.677 \pm 0.016$ MeV [u] (S = 2.8)
Mean life $\tau = (1.2386 \pm 0.0024) \times 10^{-8}$ s (S = 2.0)
$c\tau = 3.713$ m

Slope parameter g [v]

(See Particle Listings for quadratic coefficients)

$K^+ \to \pi^+ \pi^+ \pi^- = -0.2154 \pm 0.0035$ (S = 1.4)
$K^- \to \pi^- \pi^- \pi^+ = -0.217 \pm 0.007$ (S = 2.5)
$K^\pm \to \pi^\pm \pi^0 \pi^0 = 0.594 \pm 0.019$ (S = 1.3)

$K^\pm$ decay form factors [a,w]

K^+_{e3} $\lambda_+ = 0.0286 \pm 0.0022$

$K^+_{\mu 3}$ $\lambda_+ = 0.032 \pm 0.008$ (S = 1.6)

$K^+_{\mu 3}$ $\lambda_0 = 0.006 \pm 0.007$ (S = 1.6)

K^+_{e3} $|f_S/f_+| = 0.084 \pm 0.023$ (S = 1.2)

K^+_{e3} $|f_T/f_+| = 0.38 \pm 0.11$ (S = 1.1)

$K^+_{\mu 3}$ $|f_T/f_+| = 0.02 \pm 0.12$

$K^+ \to e^+ \nu_e \gamma$ $|F_A + F_V| = 0.148 \pm 0.010$
$K^+ \to \mu^+ \nu_\mu \gamma$ $|F_A + F_V| < 0.23$, CL = 90%
$K^+ \to e^+ \nu_e \gamma$ $|F_A - F_V| < 0.49$
$K^+ \to \mu^+ \nu_\mu \gamma$ $|F_A - F_V| = -2.2$ to 0.3

K^- modes are charge conjugates of the modes below.

K^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\mu^+ \nu_\mu$	(63.51 ± 0.18) %	S=1.3	236
$e^+ \nu_e$	$(1.55 \pm 0.07) \times 10^{-5}$		247
$\pi^+ \pi^0$	(21.16 ± 0.14) %	S=1.1	205
$\pi^+ \pi^+ \pi^-$	(5.59 ± 0.05) %	S=1.8	125
$\pi^+ \pi^0 \pi^0$	(1.73 ± 0.04) %	S=1.2	133
$\pi^0 \mu^+ \nu_\mu$	(3.18 ± 0.08) %	S=1.5	215

Called $K^+_{\mu 3}$.

$\pi^0 e^+ \nu_e$		(4.82 ± 0.06) %		$S=1.3$	228

Called K_{e3}^+.

$\pi^0 \pi^0 e^+ \nu_e$		(2.1 ± 0.4) $\times 10^{-5}$			206
$\pi^+ \pi^- e^+ \nu_e$		(3.91 ± 0.17) $\times 10^{-5}$			203
$\pi^+ \pi^- \mu^+ \nu_\mu$		(1.4 ± 0.9) $\times 10^{-5}$			151
$\pi^0 \pi^0 \pi^0 e^+ \nu_e$		< 3.5 $\times 10^{-6}$		CL=90%	135
$\pi^+ \gamma\gamma$	[x]	(1.10 ± 0.32) $\times 10^{-6}$			227
$\pi^+ 3\gamma$	[x]	< 1.0 $\times 10^{-4}$		CL=90%	227
$\mu^+ \nu_\mu \nu\overline{\nu}$		< 6.0 $\times 10^{-6}$		CL=90%	236
$e^+ \nu_e \nu\overline{\nu}$		< 6 $\times 10^{-5}$		CL=90%	247
$\mu^+ \nu_\mu e^+ e^-$		(1.3 ± 0.4) $\times 10^{-7}$			236
$e^+ \nu_e e^+ e^-$		(3.0 $^{+3.0}_{-1.5}$) $\times 10^{-8}$			247
$\mu^+ \nu_\mu \mu^+ \mu^-$		< 4.1 $\times 10^{-7}$		CL=90%	185
$\mu^+ \nu_\mu \gamma$	[x,y]	(5.50 ± 0.28) $\times 10^{-3}$			236
$\pi^+ \pi^0 \gamma$	[x,y]	(2.75 ± 0.15) $\times 10^{-4}$			205
$\pi^+ \pi^0 \gamma$(DE)	[x,z]	(1.8 ± 0.4) $\times 10^{-5}$			205
$\pi^+ \pi^+ \pi^- \gamma$	[x,y]	(1.04 ± 0.31) $\times 10^{-4}$			125
$\pi^+ \pi^0 \pi^0 \gamma$	[x,y]	(7.5 $^{+5.5}_{-3.0}$) $\times 10^{-6}$			133
$\pi^0 \mu^+ \nu_\mu \gamma$	[x,y]	< 6.1 $\times 10^{-5}$		CL=90%	215
$\pi^0 e^+ \nu_e \gamma$	[x,y]	(2.62 ± 0.20) $\times 10^{-4}$			228
$\pi^0 e^+ \nu_e \gamma$(SD)	[aa]	< 5.3 $\times 10^{-5}$		CL=90%	228
$\pi^0 \pi^0 e^+ \nu_e \gamma$		< 5 $\times 10^{-6}$		CL=90%	206

Lepton Family number (*LF*), Lepton number (*L*), $\Delta S = \Delta Q$ (*SQ*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes

$\pi^+ \pi^+ e^- \overline{\nu}_e$	SQ		< 1.2 $\times 10^{-8}$		CL=90%	203
$\pi^+ \pi^+ \mu^- \overline{\nu}_\mu$	SQ		< 3.0 $\times 10^{-6}$		CL=95%	151
$\pi^+ e^+ e^-$	S1		(2.74 ± 0.23) $\times 10^{-7}$			227
$\pi^+ \mu^+ \mu^-$	S1		(5.0 ± 1.0) $\times 10^{-8}$			172
$\pi^+ \nu\overline{\nu}$	S1		(4.2 $^{+9.7}_{-3.5}$) $\times 10^{-10}$			227
$\mu^- \nu e^+ e^+$	LF		< 2.0 $\times 10^{-8}$		CL=90%	236
$\mu^+ \nu_e$	LF	[d]	< 4 $\times 10^{-3}$		CL=90%	236
$\pi^+ \mu^+ e^-$	LF		< 2.1 $\times 10^{-10}$		CL=90%	214
$\pi^+ \mu^- e^+$	LF		< 7 $\times 10^{-9}$		CL=90%	214
$\pi^- \mu^+ e^+$	L		< 7 $\times 10^{-9}$		CL=90%	214
$\pi^- e^+ e^+$	L		< 1.0 $\times 10^{-8}$		CL=90%	227
$\pi^- \mu^+ \mu^+$	L	[d]	< 1.5 $\times 10^{-4}$		CL=90%	172
$\mu^+ \overline{\nu}_e$	L	[d]	< 3.3 $\times 10^{-3}$		CL=90%	236
$\pi^0 e^+ \overline{\nu}_e$	L		< 3 $\times 10^{-3}$		CL=90%	228

$$\boxed{K^0} \qquad\qquad I(J^P) = \tfrac{1}{2}(0^-)$$

50% K_S, 50% K_L

Mass $m = 497.672 \pm 0.031$ MeV

$m_{K^0} - m_{K^\pm} = 3.995 \pm 0.034$ MeV (S = 1.1)

$\left| m_{K^0} - m_{\overline{K}^0} \right| / m_{\text{average}} < 10^{-18}$ [bb]

$$\boxed{K^0_S} \qquad\qquad I(J^P) = \tfrac{1}{2}(0^-)$$

Mean life $\tau = (0.8934 \pm 0.0008) \times 10^{-10}$ s

$c\tau = 2.6783$ cm

CP-violation parameters [cc]

$\text{Im}(\eta_{+-0}) = -0.002 \pm 0.009$

$\text{Im}(\eta_{000})^2 < 0.1$, CL = 90%

K^0_S DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\pi^+ \pi^-$		(68.61 ± 0.28) %	S=1.2	206
$\pi^0 \pi^0$		(31.39 ± 0.28) %	S=1.2	209
$\pi^+ \pi^- \gamma$	[y,dd]	$(1.78 \pm 0.05) \times 10^{-3}$		206
$\gamma \gamma$		$(2.4 \pm 0.9) \times 10^{-6}$		249
$\pi^+ \pi^- \pi^0$		$(3.4 \,^{+1.1}_{-0.9}) \times 10^{-7}$		133
$3\pi^0$		$< 3.7 \times 10^{-5}$	CL=90%	139
$\pi^\pm e^\mp \nu$	[ee]	$(6.70 \pm 0.07) \times 10^{-4}$	S=1.1	229
$\pi^\pm \mu^\mp \nu$	[ee]	$(4.69 \pm 0.06) \times 10^{-4}$	S=1.1	216
$\Delta S = 1$ weak neutral current ($S1$) modes				
$\mu^+ \mu^-$	S1	$< 3.2 \times 10^{-7}$	CL=90%	225
$e^+ e^-$	S1	$< 1.4 \times 10^{-7}$	CL=90%	249
$\pi^0 e^+ e^-$	S1	$< 1.1 \times 10^{-6}$	CL=90%	231

$\boxed{K^0_L}$ $\qquad\qquad\qquad\qquad I(J^P) = \frac{1}{2}(0^-)$

$$m_{K_L} - m_{K_S} = (0.5301 \pm 0.0014) \times 10^{10} \ \hbar \ \mathrm{s}^{-1}$$
$$= (3.489 \pm 0.009) \times 10^{-12} \ \mathrm{MeV}$$
$$\text{Mean life } \tau = (5.17 \pm 0.04) \times 10^{-8} \ \mathrm{s} \quad (S = 1.1)$$
$$c\tau = 15.51 \ \mathrm{m}$$

Slope parameter g [v]

(See Particle Listings for quadratic coefficients)

$$K^0_L \to \ \pi^+ \pi^- \pi^0 = 0.670 \pm 0.014 \quad (S = 1.6)$$

K_L decay form factors [w]

$$K^0_{e3} \quad \lambda_+ = 0.0300 \pm 0.0016 \quad (S = 1.2)$$
$$K^0_{\mu3} \quad \lambda_+ = 0.034 \pm 0.005 \quad (S = 2.3)$$
$$K^0_{\mu3} \quad \lambda_0 = 0.025 \pm 0.006 \quad (S = 2.3)$$
$$K^0_{e3} \quad |f_S/f_+| \ < \ 0.04, \ \mathrm{CL} = 68\%$$
$$K^0_{e3} \quad |f_T/f_+| \ < \ 0.23, \ \mathrm{CL} = 68\%$$
$$K^0_{\mu3} \quad |f_T/f_+| = 0.12 \pm 0.12$$
$$K_L \to \ e^+ e^- \gamma: \quad \alpha_{K^*} = -0.28 \pm 0.08$$

CP-violation parameters [cc]

$$\delta = (0.327 \pm 0.012)\%$$
$$|\eta_{00}| = (2.275 \pm 0.019) \times 10^{-3} \quad (S = 1.1)$$
$$|\eta_{+-}| = (2.285 \pm 0.019) \times 10^{-3}$$
$$|\eta_{00}/\eta_{+-}| = 0.9956 \pm 0.0023 \ ^{[ff]} \quad (S = 1.8)$$
$$\epsilon'/\epsilon = (1.5 \pm 0.8) \times 10^{-3} \ ^{[ff]} \quad (S = 1.8)$$
$$\phi_{+-} = (43.5 \pm 0.6)°$$
$$\phi_{00} = (43.4 \pm 1.0)°$$
$$\phi_{00} \ - \ \phi_{+-} = (-0.1 \pm 0.8)°$$
$$j \text{ for } K^0_L \to \ \pi^+ \pi^- \pi^0 = 0.0011 \pm 0.0008$$
$$|\eta_{+-\gamma}| = (2.35 \pm 0.07) \times 10^{-3}$$
$$\phi_{+-\gamma} = (44 \pm 4)°$$
$$|\epsilon'_{+-\gamma}|/\epsilon \ < \ 0.3, \ \mathrm{CL} = 90\%$$

$\Delta S = -\Delta Q$ in $K^0_{\ell 3}$ decay

Re $x = 0.006 \pm 0.018$ (S = 1.3)

Im $x = -0.003 \pm 0.026$ (S = 1.2)

CPT-violation parameters

Re $\Delta = 0.018 \pm 0.020$

Im $\Delta = 0.02 \pm 0.04$

K^0_L DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$3\pi^0$		$(21.12 \pm 0.27$) %	S=1.1	139
$\pi^+ \pi^- \pi^0$		$(12.56 \pm 0.20$) %	S=1.7	133
$\pi^\pm \mu^\mp \nu$	[gg]	$(27.17 \pm 0.25$) %	S=1.1	216
Called $K^0_{\mu 3}$.				
$\pi^\pm e^\mp \nu_e$	[gg]	$(38.78 \pm 0.27$) %	S=1.1	229
Called K^0_{e3}.				
2γ		$(5.92 \pm 0.15$) $\times 10^{-4}$		249
3γ		$< 2.4 \quad \times 10^{-7}$	CL=90%	249
$\pi^0 2\gamma$	[hh]	$(1.70 \pm 0.28$) $\times 10^{-6}$		231
$\pi^0 \pi^\pm e^\mp \nu$	[gg]	$(5.18 \pm 0.29$) $\times 10^{-5}$		207
$(\pi \mu \, \text{atom})\nu$		$(1.06 \pm 0.11$) $\times 10^{-7}$		–
$\pi^\pm e^\mp \nu_e \gamma$	[y,gg,hh]	$(3.62 {}^{+0.26}_{-0.21}$) $\times 10^{-3}$		229
$\pi^+ \pi^- \gamma$	[y,hh]	$(4.61 \pm 0.14$) $\times 10^{-5}$		206
$\pi^0 \pi^0 \gamma$		$< 5.6 \quad \times 10^{-6}$		209

Charge conjugation × Parity (CP, CPV) or Lepton Family number (LF) violating modes, or $\Delta S = 1$ weak neutral current ($S1$) modes

			Fraction	Scale factor/ CL	p (MeV/c)
$\pi^+ \pi^-$	CPV		$(2.067 \pm 0.035) \times 10^{-3}$	S=1.1	206
$\pi^0 \pi^0$	CPV		$(9.36 \pm 0.20$) $\times 10^{-4}$		209
$\mu^+ \mu^-$	$S1$		$(7.2 \pm 0.5$) $\times 10^{-9}$	S=1.4	225
$\mu^+ \mu^- \gamma$	$S1$		$(3.25 \pm 0.28$) $\times 10^{-7}$		225
$e^+ e^-$	$S1$		$< 4.1 \quad \times 10^{-11}$	CL=90%	249
$e^+ e^- \gamma$	$S1$		$(9.1 \pm 0.5$) $\times 10^{-6}$		249
$e^+ e^- \gamma \gamma$	$S1$	[hh]	$(6.5 \pm 1.2$) $\times 10^{-7}$		249
$\pi^+ \pi^- e^+ e^-$	$S1$	[hh]	$< 4.6 \quad \times 10^{-7}$	CL=90%	206
$\mu^+ \mu^- e^+ e^-$	$S1$		$(2.9 {}^{+6.7}_{-2.4}$) $\times 10^{-9}$		225
$e^+ e^- e^+ e^-$	$S1$		$(4.1 \pm 0.8$) $\times 10^{-8}$	S=1.2	249
$\pi^0 \mu^+ \mu^-$	$CP,S1$	[ii]	$< 5.1 \quad \times 10^{-9}$	CL=90%	177
$\pi^0 e^+ e^-$	$CP,S1$	[ii]	$< 4.3 \quad \times 10^{-9}$	CL=90%	231
$\pi^0 \nu \overline{\nu}$	$CP,S1$	[jj]	$< 5.8 \quad \times 10^{-5}$	CL=90%	231
$e^\pm \mu^\mp$	LF	[gg]	$< 3.3 \quad \times 10^{-11}$	CL=90%	238
$e^\pm e^\pm \mu^\mp \mu^\mp$	LF	[gg]	$< 6.1 \quad \times 10^{-9}$	CL=90%	–

$K^*(892)$ $\qquad\qquad I(J^P) = \frac{1}{2}(1^-)$

$K^*(892)^\pm$ mass $m = 891.66 \pm 0.26$ MeV
$K^*(892)^0$ mass $m = 896.10 \pm 0.28$ MeV $\quad$ (S = 1.4)
$K^*(892)^\pm$ full width , $= 50.8 \pm 0.9$ MeV
$K^*(892)^0$ full width , $= 50.5 \pm 0.6$ MeV $\quad$ (S = 1.1)

$K^*(892)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\pi$	~ 100 %		291
$K^0\gamma$	$(2.30 \pm 0.20) \times 10^{-3}$		310
$K^\pm\gamma$	$(9.9 \pm 0.9) \times 10^{-4}$		309
$K\pi\pi$	$< 7 \times 10^{-4}$	95%	224

$K_1(1270)$ $\qquad\qquad I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1273 \pm 7$ MeV [m]
Full width , $= 90 \pm 20$ MeV [m]

$K_1(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\rho$	(42 ± 6) %	76
$K_0^*(1430)\pi$	(28 ± 4) %	–
$K^*(892)\pi$	(16 ± 5) %	301
$K\omega$	(11.0 ± 2.0) %	–
$K f_0(1370)$	(3.0 ± 2.0) %	–

$K_1(1400)$ $\qquad\qquad I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1402 \pm 7$ MeV
Full width , $= 174 \pm 13$ MeV $\quad$ (S = 1.6)

$K_1(1400)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K^*(892)\pi$	(94 ± 6) %	401
$K\rho$	(3.0 ± 3.0) %	298
$K f_0(1370)$	(2.0 ± 2.0) %	–
$K\omega$	(1.0 ± 1.0) %	285
$K_0^*(1430)\pi$	not seen	–

$K^*(1410)$ $I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1414 \pm 15$ MeV   (S = 1.3)
Full width , $= 232 \pm 21$ MeV   (S = 1.1)

$K^*(1410)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K^*(892)\pi$	> 40 %	95%	408
$K\pi$	(6.6$\pm$1.3) %		611
$K\rho$	< 7 %	95%	309

$K_0^*(1430)$ [kk] $I(J^P) = \frac{1}{2}(0^+)$

Mass $m = 1429 \pm 6$ MeV
Full width , $= 287 \pm 23$ MeV

$K_0^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(93$\pm$10) %	621

$K_2^*(1430)$ $I(J^P) = \frac{1}{2}(2^+)$

$K_2^*(1430)^\pm$ mass $m = 1425.6 \pm 1.5$ MeV   (S = 1.1)
$K_2^*(1430)^0$ mass $m = 1432.4 \pm 1.3$ MeV
$K_2^*(1430)^\pm$ full width , $= 98.5 \pm 2.7$ MeV   (S = 1.1)
$K_2^*(1430)^0$ full width , $= 109 \pm 5$ MeV   (S = 1.9)

$K_2^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K\pi$	(49.9$\pm$1.2) %		622
$K^*(892)\pi$	(24.7$\pm$1.5) %		423
$K^*(892)\pi\pi$	(13.4$\pm$2.2) %		375
$K\rho$	(8.7$\pm$0.8) %	S=1.2	331
$K\omega$	(2.9$\pm$0.8) %		319
$K^+\gamma$	(2.4$\pm$0.5) $\times 10^{-3}$	S=1.1	627
$K\eta$	($1.5^{+3.4}_{-1.0}$) $\times 10^{-3}$	S=1.3	492
$K\omega\pi$	< 7.2 $\times 10^{-4}$	CL=95%	110
$K^0\gamma$	< 9 $\times 10^{-4}$	CL=90%	631

$K^*(1680)$ $\qquad\qquad\qquad I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1717 \pm 27$ MeV   (S = 1.4)
Full width , $= 322 \pm 110$ MeV   (S = 4.2)

$K^*(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(38.7 ± 2.5) %	779
$K\rho$	$(31.4^{+4.7}_{-2.1})$ %	571
$K^*(892)\pi$	$(29.9^{+2.2}_{-4.7})$ %	615

$K_2(1770)$ [/l] $\qquad\qquad\qquad I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1773 \pm 8$ MeV
Full width , $= 186 \pm 14$ MeV

$K_2(1770)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi\pi$		−
$\quad K_2^*(1430)\pi$	dominant	287
$\quad K^*(892)\pi$	seen	653
$\quad K f_2(1270)$	seen	−
$K\phi$	seen	441
$K\omega$	seen	608

$K_3^*(1780)$ $\qquad\qquad\qquad I(J^P) = \frac{1}{2}(3^-)$

Mass $m = 1776 \pm 7$ MeV   (S = 1.1)
Full width , $= 159 \pm 21$ MeV   (S = 1.3)

$K_3^*(1780)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\rho$	(31 ± 9) %		612
$K^*(892)\pi$	(20 ± 5) %		651
$K\pi$	(18.8 ± 1.0) %		810
$K\eta$	(30 ± 13) %		715
$K_2^*(1430)\pi$	< 16 %	95%	284

$K_2(1820)$ [mm]

$I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1816 \pm 13$ MeV
Full width $\Gamma = 276 \pm 35$ MeV

$K_2(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K_2^*(1430)\pi$	seen	325
$K^*(892)\pi$	seen	680
$K f_2(1270)$	seen	186
$K\omega$	seen	638

$K_4^*(2045)$

$I(J^P) = \frac{1}{2}(4^+)$

Mass $m = 2045 \pm 9$ MeV   (S = 1.1)
Full width $\Gamma = 198 \pm 30$ MeV

$K_4^*(2045)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	$(9.9 \pm 1.2)\%$	958
$K^*(892)\pi\pi$	$(9\ \pm 5\ )\%$	800
$K^*(892)\pi\pi\pi$	$(7\ \pm 5\ )\%$	764
$\rho K\pi$	$(5.7 \pm 3.2)\%$	742
$\omega K\pi$	$(5.0 \pm 3.0)\%$	736
$\phi K\pi$	$(2.8 \pm 1.4)\%$	591
$\phi K^*(892)$	$(1.4 \pm 0.7)\%$	363