Strong Decays of Resonances and Coupling Constants (*).

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This is an updating of the Tables (**) published in November 1968 ([1]), and collects the values of the coupling constants relative to some classes of strong decays of resonances.

The method we have exploited in order to obtain simple formulae expressing such coupling constants as functions of the experimental data has been widely explained in ref. ([1]); thus, we now limit ourselves to give a few notes on the interpretation of the Tables.

Three classes of decays have been considered:

I) decays of meson resonances of spin J into two pseudoscalar mesons;

II) decays of meson resonances of spin J and natural parity into a vector meson and a pseudoscalar one;

III) decays of baryon resonances of spin J into a baryon and a pseudoscalar meson.

The coupling constants for the relative processes are defined unambiguously when we write down the explicit expression for the invariant matrix element between initial and final states.

The matrix elements, $M^{i_1 i_2 i_3}$, which correspond to the decays of the three classes listed above, are assumed to be respectively:

I) $$M^{i_1 i_2 i_3} = g_{\text{MPP}}\, C^{i_1 i_2 i_3} \varphi^{\mu_1 \dots \mu_J} P_{\mu_1} \dots P_{\mu_J} ;$$

II) $$M^{i_1 i_2 i_3} = g_{\text{MVP}}\, C^{i_1 i_2 i_3} a_\beta \varphi^{\beta\mu_2 \dots \mu_J} P_{\mu_2} \dots P_{\mu_J} ,$$

where $a_\beta = \varepsilon_{\alpha\beta\gamma\delta}\, \varepsilon_2^\alpha p_1^\gamma p_2^\delta$, $\varepsilon_{\alpha\beta\gamma\delta}$ is the Ricci tensor;

III) *a*) $$M^{i_1 i_2 i_3} = g^{(+)}_{\text{RBP}}\, C^{i_1 i_2 i_3} \bar{\psi} \Psi^{\mu_1 \dots \mu_L} P_{\mu_1} \dots P_{\mu_L}$$

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(**) We point out that some numerical calculations of the coupling constants in this reference are not correct.

([1]) G. CARBONE: *Nuovo Cimento*, **58** A, 23 (1968).

if the decaying resonance has parity $(-1)^{J+\frac{1}{2}}$.

$$b) \qquad M^{i_1 i_2 i_3} = g^{(-)}_{\text{RBP}} C^{i_1 i_2 i_3} \bar{\varphi}\gamma_5 \Psi^{\mu_1 \dots \mu_L} P_{\mu_1} \dots P_{\mu_L}$$

if the decaying resonance has parity $(-1)^{J-\frac{1}{2}}$.

We have adopted the following conventions and notations: index 1 always refers to the decaying resonance, index 3 to the pseudoscalar meson and index 2 to the remaining particle; $C^{i_1 i_2 i_3}$ indicates a Clebsch-Gordan coefficient (*); p_1, p_2, p_3 denote the four-momenta of the three particles; P is the part of p_2 orthogonal to p_1:

$$P = p_2 - \frac{p_2 \cdot p_1}{m_1^2} p_1 ;$$

$\varphi^{\mu_1 \dots \mu_J}$ is the tensor with J four-dimensional indices which describes the resonance with four-momentum p_1 and integer spin J: it is traceless, completely symmetric in the indices, and satisfies the transversality condition $p_{1\mu} \varphi^{\mu\mu_2 \dots \mu_J} = 0$;

TABLE I.

Decay mode $J \to 0^- + 0^-$	J^P	Mass (MeV)	Width (MeV)	Fraction (%)	Coupling constant $g^2/4\pi$
$\rho \to \pi\pi$	1^-	765 ± 10	125 ± 20	≈ 100	≈ 19.0
$\pi_N \to \eta\pi$	0^+	1016 ± 10	≈ 25	< 80	$< 0.12\ (\text{GeV})^2$
$\varphi \to K^+K^-$	1^-	1019.5 ± 0.6	3.7 ± 0.6	47.6 ± 1.8	11.0 ± 2.2
$\varphi \to K_L K_S$	1^-	1019.5 ± 0.6	3.7 ± 0.6	32.8 ± 1.9	11.7 ± 2.6
$\eta_{0^+} \to \pi\pi$	0^-	1070 ± 20	≈ 80	< 65	$< 0.46\ (\text{GeV})^2$
$\eta_{0^+} \to K\bar{K}$	0^-	1070 ± 20	≈ 80	> 35	$> 0.32\ (\text{GeV})^2$; $< 0.92\ (\text{GeV})^2$
$f \to \pi\pi$	2^+	1264 ± 10	145 ± 25	large	$< 77.0\ (\text{GeV})^{-2}$
$f' \to K\bar{K}$	2^+	1514 ± 5	73 ± 23	72 ± 12	$(30.0 \pm 3.0)\ (\text{GeV})^{-2}$
$f' \to \pi\pi$	2^+	1514 ± 5	73 ± 23	< 14	$< 3.08\ (\text{GeV})^{-2}$
$f' \to \eta\eta$	2^+	1514 ± 5	73 ± 23	< 40	$< 51.8\ (\text{GeV})^{-2}$
$K^* \to K\pi$	1^-	891.4 ± 0.6	49.7 ± 1.1	≈ 100	≈ 9.85
$K_N \to K\pi$	2^-	1422 ± 4	90 ± 6	51 ± 5	$(15.8 \pm 2.7)\ (\text{GeV})^{-2}$
$K_N \to K\eta$	2^-	1422 ± 4	90 ± 6	2.0 ± 1.1	$(2.10 \pm 1.31)\ (\text{GeV})^{-2}$

TABLE II.

Decay mode $J \to 1^- + 0^-$	J^P	Mass (MeV)	Width (MeV)	Fraction (%)	Coupling constant $g^2/4\pi$
$K_N \to K^*\pi$	2^+	1422 ± 4	90 ± 6	33 ± 3	$(24.7 \pm 3.9)\ (\text{GeV})^{-4}$
$K_N \to K\rho$	2^-	1422 ± 4	90 ± 6	11 ± 4	$(30.4 \pm 13.1)\ (\text{GeV})^{-4}$
$K_N \to K\omega$	2^-	1422 ± 4	90 ± 6	3.4 ± 1.2	$(11.8 \pm 4.9)\ (\text{GeV})^{-4}$

(*) The Clebsch-Gordan coefficients are normalized in such a way that $\sum_{i_2 i_3} |C^{i_1 i_2 i_3}|^2 = 1$.

TABLE III.

Decay mode $J \to \frac{1}{2}^+ + 0^-$	J^P	Mass (MeV)	Width (MeV)	Fraction (%)	Coupling constant $g^2/4\pi$
$\mathcal{N}'_{1470} \to \mathcal{N}\pi$	$(1/2)^+$	1460	260	55	5.86
$\mathcal{N}'_{1518} \to \mathcal{N}\pi$	$(3/2)^-$	1515	115	50	27.4 $(\text{GeV})^{-2}$
$\mathcal{N}_{1550} \to \mathcal{N}\pi$	$(1/2)^-$	1525	80	35	$4.69 \cdot 10^{-2}$
$\mathcal{N}_{1550} \to \mathcal{N}\eta$	$(1/2)^-$	1525	80	65	$26.0 \cdot 10^{-2}$
$\mathcal{N}_{1680} \to \mathcal{N}\pi$	$(5/2)^-$	1675	145	45	7.06 $(\text{GeV})^{-4}$
$\mathcal{N}_{1688} \to \mathcal{N}\pi$	$(5/2)^+$	1690	125	60	94.4 $(\text{GeV})^{-4}$
$\mathcal{N}'_{1710} \to \mathcal{N}\pi$	$(1/2)^-$	1715	280	65	$25.8 \cdot 10^{-2}$
$\mathcal{N}''_{1750} \to \mathcal{N}\pi$	$(1/2)^+$	1785	405	34	1.98
$\mathcal{N}_{2190} \to \mathcal{N}\pi$	$(7/2)^-$	2190	300	35	24.7 $(\text{GeV})^{-6}$
$\Delta_{1236} \to \mathcal{N}\pi$	$(3/2)^+$	1236.0 ± 0.6	120 ± 2	100	(18.9 ± 0.4) $(\text{GeV})^{-2}$
$\Delta_{1640} \to \mathcal{N}\pi$	$(1/2)^-$	1630	160	25	$6.06 \cdot 10^{-2}$
$\Delta_{1690} \to \mathcal{N}\pi$	$(3/2)^-$	1670	225	15	6.24 $(\text{GeV})^{-2}$
$\Delta_{1910} \to \mathcal{N}\pi$	$(5/2)^+$	1880	250	20	18.6 $(\text{GeV})^{-4}$
$\Delta_{1930} \to \mathcal{N}\pi$	$(1/2)^+$	1905	300	25	$83.5 \cdot 10^{-2}$
$\Delta_{1950} \to \mathcal{N}\pi$	$(7/2)^+$	1940	210	40	11.5 $(\text{GeV})^{-6}$
$\Delta_{2420} \to \mathcal{N}\pi$	$(11/2)^+$	2420	310	11	2.36 $(\text{GeV})^{-10}$
$\Lambda_{1405} \to \Sigma\pi$	$(1/2)^-$	1405 ± 5	40 ± 10	100	$16.8 \cdot 10^{-2} \pm 4.3 \cdot 10^{-2}$
$\Lambda_{1520} \to \mathcal{N}\bar{K}$	$(3/2)^-$	1518.8 ± 1.5	16 ± 2	45 ± 4	(87.3 ± 18.8) $(\text{GeV})^{-2}$
$\Lambda_{1520} \to \Sigma\pi$	$(3/2)^-$	1518.8 ± 1.5	16 ± 2	45 ± 4	(69.3 ± 14.9) $(\text{GeV})^{-2}$
$\Lambda'_{1670} \to \mathcal{N}\bar{K}$	$(1/2)^-$	1670	25	14	$0.73 \cdot 10^{-2}$
$\Lambda'_{1670} \to \Lambda\eta$	$(1/2)^-$	1670	25	33	$9.35 \cdot 10^{-2}$
$\Lambda'_{1670} \to \Sigma\pi$	$(1/2)^-$	1670	25	45	$1.98 \cdot 10^{-2}$
$\Lambda'_{1700} \to \mathcal{N}\bar{K}$	$(3/2)^-$	1690	40	25	6.88 $(\text{GeV})^{-2}$
$\Lambda'_{1700} \to \Sigma\pi$	$(3/2)^-$	1690	40	35	16.4 $(\text{GeV})^{-2}$
$\Lambda_{1815} \to \mathcal{N}\bar{K}$	$(5/2)^+$	1815 ± 5	75 ± 10	65	(103 ± 14.0) $(\text{GeV})^{-4}$
$\Lambda_{1815} \to \Sigma\pi$	$(5/2)^+$	1815 ± 5	75 ± 10	11	(35.7 ± 4.9) $(\text{GeV})^{-4}$
$\Lambda_{1830} \to \mathcal{N}\bar{K}$	$(5/2)^-$	1830	80	10	1.08 $(\text{GeV})^{-4}$
$\Lambda_{1830} \to \Sigma\pi$	$(5/2)^-$	1830	80	35	4.47 $(\text{GeV})^{-4}$
$\Lambda_{2100} \to \mathcal{N}\bar{K}$	$(7/2)^-$	2100	140	30	45.1 $(\text{GeV})^{-6}$
$\Lambda_{2100} \to \Sigma\pi$	$(7/2)^-$	2100	140	4	13.3 $(\text{GeV})^{-6}$
$\Lambda_{2100} \to \Lambda\eta$	$(7/2)^-$	2100	140	< 3	< 28.5 $(\text{GeV})^{-6}$
$\Sigma_{1385} \to \Lambda\pi$	$(3/2)^+$	1382	36	90	6.63 $(\text{GeV})^{-2}$
$\Sigma_{1385} \to \Sigma\pi$	$(3/2)^+$	1382	36	10	3.90 $(\text{GeV})^{-2}$
$\Sigma_{1765} \to \mathcal{N}\bar{K}$	$(5/2)^-$	1765 ± 5	100 ± 15	46	(10.0 ± 1.5) $(\text{GeV})^{-4}$
$\Sigma_{1765} \to \Lambda\pi$	$(5/2)^-$	1765 ± 5	100 ± 15	16	(2.40 ± 0.38) $(\text{GeV})^{-4}$
$\Sigma_{1915} \to \mathcal{N}\bar{K}$	$(5/2)^+$	1905	60	10	5.74 $(\text{GeV})^{-4}$
$\Sigma_{1915} \to \Lambda\pi$	$(5/2)^+$	1905	60	5	3.08 $(\text{GeV})^{-4}$
$\Sigma_{2030} \to \mathcal{N}\bar{K}$	$(7/2)^+$	2030	120	10	2.45 $(\text{GeV})^{-6}$
$\Sigma_{2030} \to \Lambda\pi$	$(7/2)^+$	2030	120	35	7.45 $(\text{GeV})^{-6}$
$\Sigma_{2030} \to \Sigma\pi$	$(7/2)^+$	2030	120	10	3.33 $(\text{GeV})^{-6}$
$\Xi_{1530} \to \Xi\pi$	$(3/2)^+$	1531	7.3	100	4.16 $(\text{GeV})^{-2}$

ε_2 is the polarization vector of the vector meson;

ψ is the spinor representing the baryon with spin $\frac{1}{2}$;

$\Psi^{\mu_1 \dots \mu_L}$ is the Rarita-Schwinger spinor with $L = J - \frac{1}{2}$ four-dimensional indices describing the baryon resonance of spin J: it is completely symmetric in the indices and fulfills the conditions

$$\gamma_{\mu_1} \Psi^{\mu_1 \dots \mu_L} = 0 , \qquad (\gamma \cdot p_1 - m_1) \Psi^{\mu_1 \dots \mu_L} = 0 .$$

Data and results quoted in the Tables are ordered in the following way: in the first column, we list the decay modes and in the successive ones the known experimental data about the decaying particle: spin and parity, mass, total width, partial width for the considered decay mode expressed as percentage of the total width; in the last column, one can read the calculated value of $g^2/4\pi$.

In the few cases in which the experimental errors on the total and partial width and on the mass of the resonance are known with sufficient accuracy, the resulting error on $g^2/4\pi$ has also been evaluated.

All the experimental data are those quoted in the Tables of Rosenfeld *et al.* of January 1969 (2).

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(2) A. H. Rosenfeld *et al.*: *Review of Particle Properties*, January 1969, UCRL-8030 Pt 1.