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STRUCTURE AND DECAY MODES OF ORDINARY MESONS

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Abstract

We use the rishon structure of the ordinary mesons and the experimentally well established decay modes of these particles to obtain their graphical structure. A remarkable regularity is found and allows a prediction on the decay modes of the η_c and η'_c charmonium.

In recent papers [1-4] we have shown how one could describe leptons, quarks and hadrons on the same footing. Introducing the graphical representation of the rishon R (the charged rishon T and the neutral rishon V) and the fundamental hypothesis that " particles are the invariants (scalars) of the colour space " one obtained

$$
\begin{aligned}
&\text{i)} \quad \text{leptons} && \ell = (\vec{R} \wedge \vec{R}) \cdot \vec{R} = \vec{R}^{*} \cdot \vec{R} \\
&\text{ii)} \quad \text{quarks} && q_c^f = \vec{f} = (\vec{R} \wedge \vec{R}) \wedge \vec{R}' = \vec{R}^{*} \wedge \vec{R}' \\
&\text{iii)} \quad \text{ordinary mesons} && M_2 = \vec{f}_1 \cdot \vec{\bar{f}}_2 = (\vec{R}_1^{*} \wedge \vec{R}'_1) \cdot (\vec{R}_2^{*} \wedge \vec{R}'_2) \\
&\text{iv)} \quad \text{baryons} && B_3 = (\vec{f}_1 \wedge \vec{f}_2) \cdot \vec{f}_3
\end{aligned}
\qquad (1)
$$

One could then assign a graphical representation to the leptons, mesons , baryons and to the exchanged bosons γ Z^{o} $W^{\pm}$ and $G_{c'}^{c}$ gluon .

One finds the $\pi^{o} = u\bar{u}$ or $d\bar{d}$ as

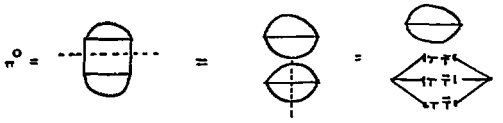
$\pi^{o} =$  (2)

while

$\pi^{+} = (u\bar{d}) =$  (3)

We show in this paper that the decay modes of the mesons is directly linked to their graphical structure. We begin with the 0^{-} states.

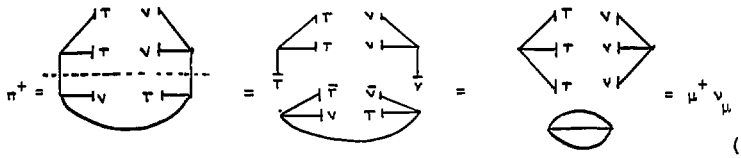
We first find the π^{o} (134.96 MeV) which mostly decay in two photons (98.85 %) [5]. This corresponds to a cut of the rishon lines



(4)

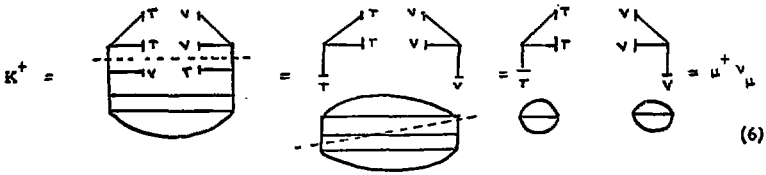
One of the obtained photon has been separated into an $e^+ e^-$ pair (1.15 %).

The next meson is the $\pi^\pm$ (131.57 MeV) which gives in a leptonic decay (100 %) two leptons of second generation

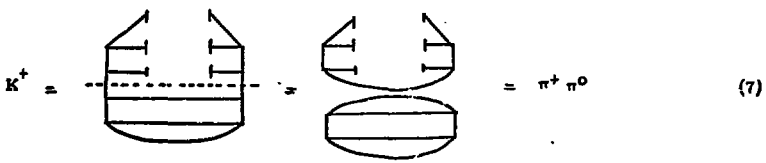


(5)

At 493.6 MeV one finds the $K^\pm$ which can decay into a $\mu^\pm \nu_\mu$ (63.5 %) or a $\pi^+ \pi^0$ (21.16 %). This can be obtained if one assignes a graphical representation with 6 rungs in a ladder

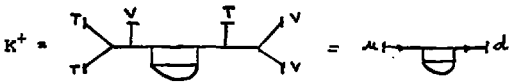


(6)



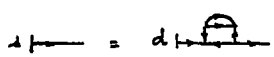
(7)

The K^+ is usually described by the $(u\bar{s})$ flavours, if one opens the diagram one finds



(8)

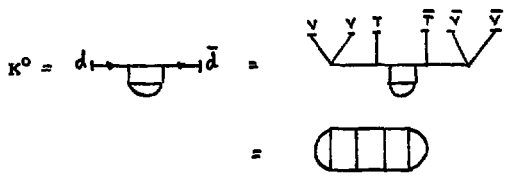
One recognizes the u-flavour at the left and the remaining s-flavour becomes



(9)

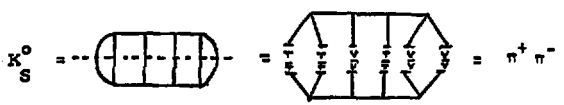
It confirms our hypothesis [4] on the generation of quarks.

The next meson (497.67 MeV) one finds is the K^0 (50 % K_L^0 and 50 % K_S^0) and the K^0 is a $d\bar{s}$ ($\bar{K}^0$ is indeed a $\bar{d}s$). If one uses the above graphical representation it comes



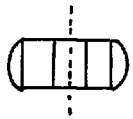
(10)

One gets a ladder with 6 rungs and a vertical cut on the 6 lines (a three-by-three cut corresponds to a strong interaction decay)

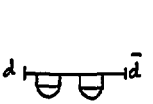
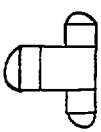
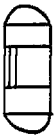


(11)

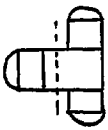
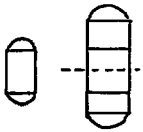
while a vertical cut gives

K^o_S =  =   = $\pi^o \pi^o$ (12)

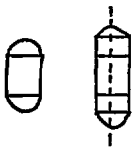
Such a diagram thus represents the K^o_S since the first decay is effectively obtained with a branching ratio of 68.6 % and the second with 31 % . The K^o_L corresponds to the same $(u\bar{s})$ states but two gluon-bubbles appear on the rishon line

K^o_L =  =  =  (13)

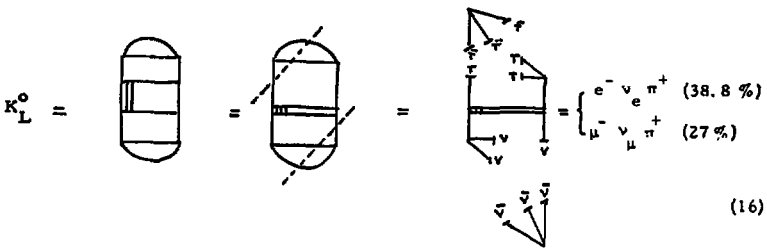
A cut on the rishon lines gives effectively

K^o_L =  =  = $\pi^o \pi^o \pi^o$ (21.5 %) (14)

The second diagram may be separated into a $\pi^+ \pi^-$ pair

K^o_L =  = $\pi^o \pi^+ \pi^-$ (12.9 %) (15)

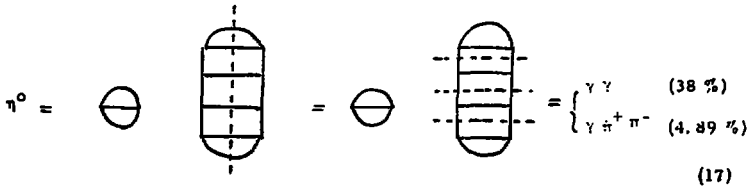
The representative diagram of the K^o_L is still a six-rungs ladder if one does not take into account the horizontal gluon-bubble



(16)

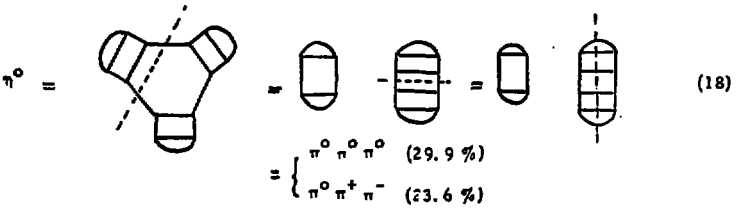
It is worthwhile to note that the K^o meson exhibits a saturation process : a flavour with one or two gluon bubbles corresponds to the same flavour state [4].

The next ordinary meson is the η^o (548.8 MeV) and one may expect it to be a eight-rungs ladder. One gets a decay into photons (38 %) by a cut on all its vertical rishon lines, or by isolating a six-rungs ladder giving thus $\pi^+\pi^-\gamma$ (4.89 %)



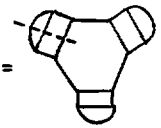
(17)

It seems however that an analog structure to the K_L^o diagram may describe its decay into $3\pi^o$ (29.9 %) or into $\pi^+\pi^-\pi^o$ (23.6 %)

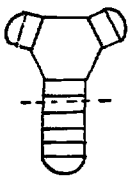
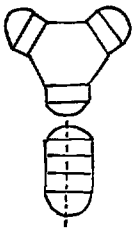


(18)

One can note that if one assigns the above diagram to the η^0, the quark structure of such a meson is probably $(s\bar{s})$ corresponding to a hidden strangeness since

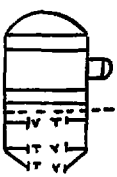
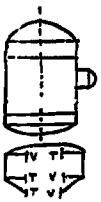
$\eta^0 =$  $= d\,\bar{d} = s\,\bar{s}$ (19)

The η'^0 (958 MeV) gives $\eta^0 \pi\pi$ (66.2 %) or $\rho^0\gamma$ (29.6 %); this probably corresponds to an excited state of the η^0 represented by a diagram with a 8 - rungs ladder.

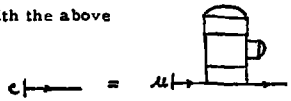
$\eta'^0 =$  $=$  $= \eta^0 \pi\pi$ (66.2 %) (20)

$=$  $= \rho^0\gamma$ (29.6 %) (21)

One finds at 1868 MeV the $D^{\pm}$ mesons and the known decay modes seem to indicate the following structure

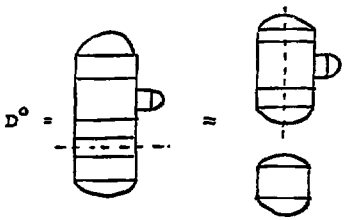
$D^+ =$  $=$  $= \begin{cases} K^0\pi^+ & (1.5\ \%) \\ \pi^+ K^-\pi^+ & (3.5\ \%) \end{cases}$ (22)

Since the D^+ is generally described with the $\bar{d}c$ quark-structure one gets with the above



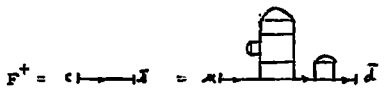
(23)

This is confirmed by the decay modes of the D^0 (1863 MeV) [6]

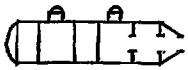


$= K^- \pi^+ \pi^0$ (12 %) (24)

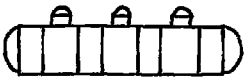
The knowledge of the rishon structure of the charmed flavour (23) gives the structure of the $F^+ (c\bar{s})$ and $\eta_c (c\bar{c})$ mesons as well as the η_c' meson as an excited state of the η_c



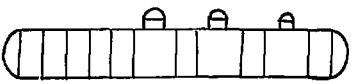
(25)



(26)



We have then built up a 10-rungs ladder with three gluon bubbles for the η_c and the Table 1 gives some proposed decay modes for F^+ and η_c mesons. The η'_c will be described by an analog diagram with 14-rungs in the ladder

η'_c =  (27)

This systematic study of the diagrammatic structure of the 0^- states of the ordinary meson shows an apparent link between the mass of the mesons and the rungs number in the ladder representative diagram (Table 1).

The study of the 1^- states of the ordinary mesons with the same procedure gives their diagrammatic structure and one finds a systematic shift with the 0^- states. The ρ^o appears to be a 6-rungs ladder (analog to the K^o_S), the ω^o is analog to the η^o, the K^{*o} to the K^o_L, the ϕ^o to the η'^o (Table 2). Such a shift is probably linked to the energy shift between the 1^- and the 0^- states of the mesons.

References

[1] E. Elbaz, J. Meyer, Report LYCEN 8017 to be published in Lettere al Nuovo Cimento.

[2] E. Elbaz, J. Meyer, Report LYCEN 8019 to be published in Lettere al Nuovo Cimento.

[3] E. Elbaz, J. Meyer, Report LYCEN 8009 to be published in Nuovo Cimento.

[4] E. Elbaz, J. Meyer, R. Nahabetian, Report LYCEN 8028 (avril 1980).

[5] Particle data group, Review of particles properties, Phys. Lett. 75B (1978); all the others unreferenced masses and branching ratios are taken in this paper.

[6] G. Wolf, DESY Report 80/13, February 1980. Lectures given at the 1979 JINR-CERN School of Physics, Dobogokö, Hungary, September 2-15, 1979.

Table Captions

Table 1 : 0^- states of the ordinary mesons. Their proposed structures and observed decay modes.

Table 2 : 1^- states of the neutral ordinary mesons. Their proposed structures and observed decay modes.

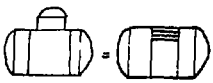
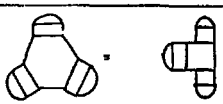
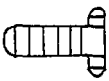
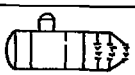
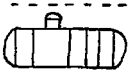
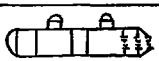
States	Runge	Particle	Mass (MeV)	Quarks	Diagrams	Decay modes (%)
0^-	4	π^0	134.96	$u\bar{u}$, $d\bar{d}$		$\gamma\gamma$ (98.85) γe^+e^- (1.15)
		π^+ (π^-)	139.57	$u\bar{d}$ ($\bar{d}u$)		$\mu^+\nu_\mu$ (100)
	6	K^+ (K^-)	493.60	$u\bar{s}$ ($\bar{s}u$)		$\mu^+\nu_\mu$ (63.5) $\pi^+\pi^0$ (21.16) $\pi^+\pi^+\pi^-$ (5.59)
		K^0_S (K^0_S)	497.67	$d\bar{s}$ ($\bar{d}s$)		$\pi^+\pi^-$ (68.6) $\pi^0\pi^0$ (31.4)
		K^0_L (K^0_L)		$d\bar{s}$ ($\bar{d}s$)		$\pi^0\pi^0\pi^0$ (21.5) $\pi^+\pi^-\pi^0$ (12.4) $\pi^+\mu^-\nu_\mu$ (27.) $\pi^+e^-\nu_e$ (38.8)
		η^0	548.8	$s\bar{s}$		$\gamma\gamma$ (38.) $\pi^0\gamma\gamma$ (3.1) $\pi^0\pi^0\pi^0$ (29.9) $\pi^+\pi^-\pi^0$ (23.6)
	8	η'^0	958	$s\bar{s}$		$\eta^0\pi\pi$ (66.2) $\rho^0\gamma$ (29.8)
		D^+ (D^-)	1868	$\bar{d}c$ ($d\bar{c}$)		$\pi^+\pi^+K^-$ (3.5) $K^0\pi^+$ (1.5)
		D^0	1863	$\bar{u}c$ $u\bar{c}$		$K^0\pi^+\pi^-$ (3.5) $K^-\pi^+\pi^0$ (12.) $K^-\pi^+\pi^+\pi^-$ (2.7)
		F^+ (F^-)	2030	$c\bar{s}$ ($s\bar{c}$)		$K^0_L\pi^0\pi^+$ (?) $K^+K^0_L$ (?) π^0D^+ (?)
	10	η_c	2976	$c\bar{c}$		$\pi^\pm K^\mp K_S$ (9)

Table 1

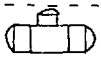
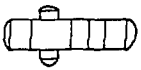
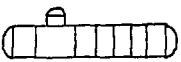
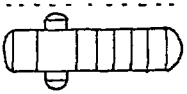
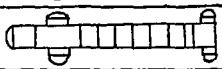
States	Runge	Particle	Mass (MeV)	Quarks	Diagrams	Decay modes (%)
1^-	6	ρ^0	770	$u\bar{u}$ $d\bar{d}$		$\pi^0\pi^0$ $\pi^+\pi^-$ (100)
		ω^0	782.6	$u\bar{u}$ $d\bar{d}$		$\pi^+\pi^-\pi^0$ (89) $\pi^+\pi^-$ (1.3) $\pi^0\gamma$ (8.8)
	8	K^{*0}	892	$d\bar{s}$		$K^0\pi^0$
		ϕ^0	1020	$s\bar{s}$		K^+K^- (48.6) $\pi^0\pi^+\pi^-$ (14.7) $K_S^0K_L^0$ (35.1)
	10	ρ'^0	1600	$u\bar{u}$ $d\bar{d}$		4π (75) $\pi^+\pi^-$ (25)
		D^{0*}	2010	$u\bar{c}$ $\bar{u}c$		$D^0\pi^0$ (55) $D^0\gamma$ (45)
		J/Ψ	3097	$c\bar{c}$		$\pi^+\pi^-\pi^0$ (7) $\pi^+\pi^-\pi^0K^+K^-$ (12) $p\pi$ (1.1)
	12	Ψ'	3685	$c\bar{c}$		$J/\Psi\pi^+\pi^-$ (33) $J/\Psi\pi^0\pi^0$ (17) $J/\Psi\eta^0$ (4.2)
	14	Ψ	3770	$c\bar{c}$		$D\bar{D}$ dominant
		Ψ	4415	$c\bar{c}$		

Table 2