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Bit-Oriented Mesons

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Abstract

In this work, the masses of the mesons π, ρ±, ρ⁰, η, and η′ are determined by applying the formula from [1, f(15)], starting from dimensionless bare-quark masses. Mesons are described here as *bit-oriented*, since powers of two play a dominant role in the expressions, followed by a spatial correction involving the constant π, primarily through its position within the formula structure. This minimalist approach yields results comparable to experimental uncertainties.

1. From iteration to bit-oriented meson masses

Mesons appear at the very source of hadronization, where point-like quarks enter linear relations during the transition from the non-spatial to the spatial domain. For the calculation of meson masses, the following assumptions are adopted:

1. The fundamental particle ***f*** is unique as a limiting value, while in hadronization it appears as a virtual, repeatable unit.
2. ***π*** and ***ρ*** mesons are formed in the first iteration from two quarks, while the η meson also includes the ***s*** quark, which thus becomes a constituent quark of the meson.
3. The dominant distinction among parameters is realized through the application of *powers of two* with integer or half-integer exponents.
4. Corrections to the obtained results are introduced through a spatial factor primarily dependent on the mathematical constant π.

These results are presented in the table *"Meson Masses"*. In its upper part, the input values of quark masses in units of **[MeV/c²]**, taken from [1, Table], are given. Since the masses of a quark and its corresponding antiquark are equal, the applied formulas are further simplified.

The table contains the following:

- In the upper part of the first column, the types of quarks participating in meson formation are listed.
- The **second** column contains experimentally measured quark and meson masses.
- In the **third** column, the same masses are converted into the **[fc]** unit system, which represents a natural system and is related to the proton via relation (1):

$$m_f = \left[2\pi \cdot 2^{[4/3\ -\ 2/(3\mu\alpha+6)]}\right]^{-1} \cdot m_p = 1.08862171 \cdot 10^{-28} kg = 61.0672 MeV/c^2 \qquad \textbf{(1)}$$

where μ is the proton-to-electron mass ratio and α is the fine-structure constant.

- In the upper part of the **fourth** column, formula (2) is applied to obtain quark masses by iteration (x_n denotes the quark mass in the n-th iteration). In the lower part, formulas (3)–(7) are applied to the quark masses in the **[fc]** system, which have no physical meaning in units of **[MeV/c²]**. Quark masses are denoted by the initial letters of their English names, and meson masses are calculated using only the binary factor.

$$x_n = x_{n-1} + x_{n-1}^{-0.5} \qquad \textbf{(2)}$$

- In the **fifth** column, the mass of the same quark is calculated more accurately with the inclusion of a spatial factor.

$$\pi^{\pm} = 2^{-2}\cdot u + 1 + 1/(2^{10}+2^{5}) \qquad \textbf{(3)}$$

$$\pi^{0} = 2^{-2}\cdot(u + d) + 1/(2^{7}+2^{6}+2^{2}+2^{1}) \qquad \textbf{(4)}$$

$$\rho^{\pm} = 2^{1/2}\cdot(u+d) \qquad \textbf{(5a)} \qquad\qquad \rho^{\pm} = [2^{7/2}\cdot\pi^{2}+3/(7\cdot 2^{1/2})]\,/\,(u+d) \qquad \textbf{(5b)}$$

$$\rho^{0} = 2^{1/2}\cdot(u + d) \qquad \textbf{(5c)} \qquad\qquad \rho^{0} = [2^{7/2}\cdot\pi^{2} + 5/(11\cdot 2^{1/2})]\,/\,(u+d) \qquad \textbf{(5d)}$$

$$\eta = 2^{-1/2}\cdot(u + d + s) + 1 + 1/(2\pi^{2}) \qquad \textbf{(6)}$$

$$\eta' = 2^{1/2}\cdot(u + d + s) - 1/2\pi \qquad \textbf{(7)}$$

- In the **sixth** column, the values from the fifth column are converted into [MeV/c²] for direct comparison with experimental data.
- In the **seventh** column, the relative error of the results from the fourth column is determined using formula (8):

$$R_g\% = 100\cdot\left(m_{fc} - m_{form}\right)/\,m_{fc} \qquad \textbf{(8)}$$

- In the **eighth** column, the relative error of the results from the fifth column is given, also according to formula (8).

Table – Meson Masses

1	2	3	4	5	6	7	8	9
Kvark	**[MeV/c²]**	**u [fc]**	**(1)**					
strange =	96.9745	1.588	**2.4**					
fund. p. =	61.0672	**1**						
down =	4.6970	0.077	**3.7**					
up =	2.3480	0.038	**5.1**					
formula	mereno	**[fc]**	**form.**	**form.**	**[MeV/c²]**	***(8)***	***(8)***	**R_g%**
$\pi^{\pm}$ (3)	139.570	**2.2855**	**2.2846**	**2.2855**	139.570	0.0413	-0.0002	0.00025
π^{0} (4)	134.977	**2.2103**	**2.2052**	**2.2103**	134.976	0.2289	0.0004	0.00037
$\rho^{\pm}$ (5a),(5b)	775.11	**12.693**	**12.475**	**12.693**	775.13	1.7178	-0.0026	0.03–0.06
ρ^{0} (5c),(5d)	775.26	**12.695**	**12.475**	**12.695**	775.26	1.7368	0.0003	0.03–0.06
η (6)	547.862	**8.9715**	**8.9214**	**8.9720**	547.90	0.55846	-0.0062	0.00300
η' (7)	957.78	**15.6840**	**15.8427**	**15.6836**	957.75	-1.012	0.0030	0.00600

- The **ninth** column shows experimental measurement uncertainties taken from the literature.

For $\boldsymbol{\pi}$ mesons, which are closest in mass to the fundamental particle, spatial effects do not become significant; therefore, corrections are realized through the additive application of *powers of two*, without the appearance of the constant π. The mass difference between $\boldsymbol{\pi}^{\pm}$ and $\boldsymbol{\pi}^{0}$, despite the same *power of two*, originates from the hadronization of the fundamental particle ***f*** (value 1 in the **[fc]** system) into $\boldsymbol{\pi}^{0}$, rather than from the ***d*** quark as an independent mass contribution.

For the $\boldsymbol{\rho}$ mesons in expressions (5a) and (5c), a relative deviation is noticeable, while the reduced mass remains close to the value 4π, motivating the use of the reciprocal structure in (5b) and (5d). The appearance of the constant 2π in expressions (5b) and (5d) indicates a geometric component, while ratios of prime numbers emerge as discrete corrective factors within an already quantized framework. The experimental masses of $\boldsymbol{\rho}$± and $\boldsymbol{\rho}^{0}$ differ within measurement uncertainties, with slightly shifted central values, which is consistent with the results obtained from the formulas.

Hadronization of the fundamental particle, as in the case of $\boldsymbol{\pi}^{\pm}$, also appears for the η meson, with a spatial corrective factor outside the power-of-two structure. For the $\boldsymbol{\eta}'$ meson, the sign of the binary exponent and the spatial factor changes, accompanied by a lower power of the constant π.

2. Conclusion

Meson masses are determined predominantly by powers of two, with an additional spatial factor associated with the constant π. The model is internally consistent and reproduces meson masses without free parameters or QCD constants. Relative deviations remain at the level of experimental uncertainties.

References

[1] Zivlak, B.: February 13 2021, Masa Neutrona iz Masa Kvarkova, Kako?
https://www.gsjournal.net/Science-Journals/Research%20Papers/View/8398