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The Fundamental Relationship between Harmonic Quark Masses and Reduced Max Planck Constant

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Abstract

O. A. Teplov developed an approach to describe the meson quark model by establishing a mathematical quark series (harmonic quark series). With respect to the physical mesons, he made some basic hypotheses of his own and used the well-known theory of harmonic oscillation to construct a numerical mass series that obeys a rigid multiplicative pattern and allows the physical meson masses to be calculated accurately. We have found that his numerical quark series, *i.e.*, their masses, has a fundamental relation to the reduced Max Planck constant ħ and report on it in the present paper. This discovery is obviously a theoretical contribution to the correctness of Teplov's harmonic quark model approach and at the same time a confirmation of the importance of this simple and powerful research work.

Keywords

Harmonic Quark Oscillator, Teplov Mass Series, Mesons, Reduced Planck Constant, Quantization of Mass, Modular Structure of Matter, YY Model

1. Introduction

In the research field of the constitution of subatomic particles, which is mainly based on the Standard Model, quarks of different flavors or generations play a central but sometimes ambivalent role: On the one hand, for example, the electric charges and spins of all quarks are well known. On the other hand, their masses can only be specifically predicted depending on the underlying constituent models, also because quarks are not directly observable.

O. A. Teplov has made an interesting approach to explain how mesons (mainly as paired quark-antiquarks) consist of a constant set of so-called harmonic quarks, which are not necessarily present in the particle zoo of the Standard Model. He was able to show that his model works accurately for the mesons, both in numeric and in capturing the completeness of the mass-energy spectra. Moreover, his mass series are theoretically based on standard harmonic oscillation theory, which is simply constructed, although the mass values themselves are determined on an evident basis, namely by calculating the possible combinations of meson masses given by the Standard Model.

Our discovery shown in this article will make his model approach more attractive and better justified in theory. However, it leaves open points for further research, the pursuit of which could unearth more interesting and fundamental facts for the creation of a universal design model for subatomic particles.

2. Harmonic Quark Model and Series

Between 2002 and 2005, O. A. Teplov introduced the concept of harmonic quarks based on oscillating quark-antiquark pairs and developed a simple and rigid formalism to calculate the masses and energy spectrum of harmonic quark oscillators (Ref. [1] [2] [3] [4]). According to this approach, the quark mass is understood as the physical rest mass of the single particle state of an interacting quantum field. The flavor quantum number (reflecting the quark production) is essentially a reflection of the quark's internal energy—its physical mass. The quark mass model deals with the mass transformation between quark flavors, focusing on the quark-antiquark interaction and its outcome: either a meson (e.g., a vector boson) or complete annihilation of the pair with the birth of photons or lower mass quarks or other particles is produced.

Consider the flavor changes in the weak fundamental interaction of quarks as expressed in the following terms (n is the quark generation number, ν is the neutrino):

$$Q_{(n)} + W_{+/-} \sim Q_{(n+1)} \tag{1}$$

$$Q_{(n)} + e_{+/-} \sim Q_{(n+1)} + \nu \tag{2}$$

Teplov derived the formula for calculating the mass of harmonic quarks based on a multiplicative pattern:

$$\begin{gathered} m_{(n+1)} = \frac{\pi}{4-\pi} \times m_{(n)} \\ m_{(n)} = \left(\frac{\pi}{4-\pi}\right)^{n} \times m_{(0)} \end{gathered} \tag{3}$$

The mass of the generation $n + 1$ quark oscillator can be determined exactly by the mass of its lower generation n, starting from a hypothetical initial mass of the generation 0 quark. Moreover, for a given quark, its two neighboring quarks can be considered as an up-ward excitation (with larger mass) and a down-ward excitation (with smaller mass), with the electric charges of the two excitations being equal. All generations of harmonic oscillators form a series of a kind of mathematical down and up quarks, including the electrical properties corresponding to the Standard Model. This series starts with the lightest down quark $m_{(0)}$ (with a mass of 28.815 MeV) by successive up excitations according to formula (3), **Table 1**.

We call them "Teplov's harmonic quark oscillators" or "Teplov's harmonic quark series". With their help, Teplov developed a mass composition model and recalculated the masses and energy spectrum for some leptons and baryons—numerically accurately. His quark generation model also accounts for the unitary decay process between quark generations n and $n + 1$ by binding an electron or positron of its flavor (its own generation), as expressed in formula (2).

Starting from the harmonic curd mass of a certain generation n, the mass of the next lower generation $n - 1$ can be calculated by reversing formula (3):

$$m_{(n-1)} = \frac{4-\pi}{\pi} \times m_{(n)} \tag{3'}$$

Therefore, it is very easy to extend his series "down-wards" to obtain harmonic quarks with low mass. For Teplov, the harmonic quark mass of $m_{(0)}$ = 28.815 MeV was considered the "lower limit". He did also mention a possible "down excitation" quark with a harmonic oscillator mass of about 7.87 MeV (Ref. [2]), calculated by 28.815 × (4 − π)/π. But he did not pursue this idea, nor the possible other down-ward excited harmonic quarks.

The authors of the current work have extended the range of downward excited Teplov quarks to include several smaller harmonic quarks, as shown in **Table 2** below.

Based on the values in both **Table 1** and **Table 2**, we used an iterative constitution approach to recalculate the physical masses of subatomic particles from the Standard Model—down quark, up quark, and basic baryons such as electron, neutron, proton, deuteron, and dineutron (Ref. [5]). An extended model approach for modular constitution was used, since the Teplov approach was focused on the quasi-annihilation state of harmonic pairs, which was not sufficient for considering smaller particles below the meson range. The authors developed the so-called "YY model", showing that a constitutional model must consider

Table 1. The masses of harmonic quarks after Teplov.

Harmonic quark named by Teplov	down	up	strange	charm	bottom	top	b'
Harmonic quark mass (MeV)	28.815	105.456	385.95	1412.5	5169.4	18,919	69,239
Notation with generation index	Q_0	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6

Table 2. The masses of (extended) harmonic quarks after "down excitation" using formular (3').

Harmonic quark extended by Yangs	-	-	-	-	-	-	-	?
Harmonic quark mass (MeV)	0.00089	0.00328	0.0120	0.0439	0.161	0.588	2.151	7.87
Notation with generation index	Q_{-8}	Q_{-7}	Q_{-6}	Q_{-5}	Q_{-4}	Q_{-3}	Q_{-2}	Q_{-1}

not only harmonic pairing, but also the triple bonding of harmonic quarks bounded by their quantum colors (Ref. [6]).

3. Fundamental Relationship to Reduced Max Planck Constant by Down-Ward Calculation

If we do not limit the hypothetical $m_{(0)}$ to 28.815 MeV, but successively reduce it to a putative final quantum value: let us call it $y_{(0)}$—"yet another zero", we obtain a very surprising result: directed to the final effective quantum of energy, the Max Planck constant (h) and the reduced Planck constant of Dirac ($\hbar$), (Ref. [7] and [8]):

$$h = 4.13566769692\cdots\times10^{-15}\ \text{eV}\cdot\text{s} \tag{4}$$

$$2\hbar = \frac{h}{\pi} = 2\times0.6582119569\cdots\times10^{-15} = 1.3164239138\cdots\times10^{-15}\ \text{eV}\cdot\text{s} \tag{5}$$

and starting from a harmonic quark Q_0 of mass $m_{(0)}$ = 28.815 MeV, a fundamental relation between the harmonic quark masses and the reduced Planck constant is immediately obtained as follows:

$$\begin{aligned}\left(\frac{4-\pi}{\pi}\right)^{29}\times(28.815\ \text{MeV}) &= \left(4.56838858\cdots\times10^{-17}\right)\times\left(28.815\times10^{6}\ \text{eV}\right)\\ &= 1.31638117\cdots\times10^{-15}\times10^{6} \approx 2\hbar\times10^{6}\end{aligned} \tag{6}$$

Except for a unit factor of one million (to be explained later), the numerical deviation is only about 0.00003 percent. The expected smallest harmonic quark $y_{(0)}$ has an exactly quantized mass with respect to the reduced Max Planck constant as follows:

$$y_0 = 2\hbar\times10^{6}\ \text{eV} \tag{7}$$

Starting from this initial mass, a complete set of harmonic quarks in the sense of Teplov can be derived by extending his originally considered range with the mass for any generation i:

$$m_i = \left(\frac{\pi}{4-\pi}\right)^{i} y_0 \tag{8}$$

It should also be noted that the formulas (7) and (8) relate the mass unit and the energy quantum. Using (7) and (8), Teplov's harmonic quark masses for the meson constitution can be accurately recalculated as follows:

$$2\hbar\times\left(\frac{\pi}{4-\pi}\right)^{29}\times10^{6} = \left(\frac{\pi}{4-\pi}\right)^{29} y_0 = 28.8159\ \text{MeV} \tag{9.1}$$

$$2\hbar\times\left(\frac{\pi}{4-\pi}\right)^{30}\times10^{6} = \left(\frac{\pi}{4-\pi}\right)^{30} y_0 = 105.4603\ \text{MeV} \tag{9.2}$$

$$2\hbar\times\left(\frac{\pi}{4-\pi}\right)^{31}\times10^{6} = \left(\frac{\pi}{4-\pi}\right)^{31} y_0 = 385.9630\ \text{MeV} \tag{9.3}$$

$$2\hbar\times\left(\frac{\pi}{4-\pi}\right)^{32}\times10^{6} = \left(\frac{\pi}{4-\pi}\right)^{32} y_0 = 1412.5443\ \text{MeV} \tag{9.4}$$

$$2\hbar \times \left(\frac{\pi}{4-\pi}\right)^{33} \times 10^{6} = \left(\frac{\pi}{4-\pi}\right)^{33} y_0 = 5169.6187 \text{ MeV} \tag{9.5}$$

$$2\hbar \times \left(\frac{\pi}{4-\pi}\right)^{34} \times 10^{6} = \left(\frac{\pi}{4-\pi}\right)^{34} y_0 = 18919.7312 \text{ MeV} \tag{9.6}$$

$$2\hbar \times \left(\frac{\pi}{4-\pi}\right)^{35} \times 10^{6} = \left(\frac{\pi}{4-\pi}\right)^{35} y_0 = 69242.2878 \text{MeV} \tag{9.7}$$

These exactly calculated values starting from the reduced Max Planck constant are compared in the following **Table 3** with the values originally estimated by Teplov.

4. In Summary

- Using a very basic harmonic oscillation theory and some plausible hypotheses, Teplov developed a harmonic quark model with a rigid multiplicative calculation pattern for the mass values.
- He determined the mass values of a certain set of harmonic mass series to constitute the physical masses of mesons, very precisely and worked well (**Table 1**, $Q_1, \ldots, Q_7$).
- By applying his multiplicative pattern 29 generations down, the authors of the present paper arrived at the final quantized harmonic quark mass value, which is almost twice the reduced Max Planck constant, multiplied by a factor of 1 million (=> megahertz).

Is the coincidence of the empirically determined series of values with the reduced Max-Planck constant (formula (7) and (8)) a stroke of luck? Rather not. We see this as a fundamental correlation. What does this fact imply? Let us give some hints in the following.

5. Conclusion and Implication

The main content of this paper is the report of our discovery of a fundamental relation expressed in the formulas (7) and (8): Starting from a quantized initial value corresponding exactly to the reduced Max-Planck constant $y_{(0)}$, a series of mathematically calculated harmonic quarks $m_{(i)}$ can be constructed. The "middle range" of this series will represent the early values estimated by Teplov in his research work on mesons (**Table 1**). The "small range" of this series represents the extended values we calculated in the early research for physical quarks and baryons. Both ranges of harmonic quarks appear to be numerically accurate and

Table 3. Comparison of calculated masses of harmonic quarks with estimated values by Teplov.

Harmonic quark defined by Teplov	down	up	strange	charm	bottom	top	b'
Estimated quark mass (MeV)	28.815	105.456	385.95	1412.5	5169.4	18,919	69,239
Calculated up-wards from $2\hbar$	28.816	105.460	385.963	1412.54	5169.62	18,919.7	69,242.3

attractive for constructing physical subatomic particles. Thus, more attention should be paid in the future to Teplov's research approach and, more generally, to approaches to the modular constitution of matter such as the YY model.

There are still unanswered questions:

- How is the factor of one million in formula (7) to be interpreted physically?
- What does the smallest harmonic quark with the mass given in formula (7) mean? Is it possible that it represents the smallest physical particle?
- How do the (mathematical) harmonic quarks manifest their physical existence (observability or their manifestation in the physical processes of collisions)?
- In the series of harmonic quarks of formula (8) there is a certain quark with a mass of 2.151 MeV, calculated by:

$$m_{27} = \left(\frac{\pi}{4-\pi}\right)^{27} y_0 = 2.151393\ \text{MeV} \tag{10}$$

It corresponds to Q_{-2} in **Table 2** and is possibly the up quark of the standard model. What are the specific conditions for this in terms of the energy spectrum?

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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