Precise mass spectrum of mesons with open charm in the harmonic quarks and oscillators.

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Abstract

The harmonic quarks and their complete oscillators are presenting the unprecedented exact solution for the mass spectrum of mesons with an explicit charm. The experimental and calculated spectrums coincide with standard deviation in 1.8 MeV. The four doublets and experimental errors of meson masses give the main contribution in this value. The harmonic spectrum is not sensitive to an isospin. The spectrum is simple, complete, precise and logically clear. It’s easy to make predictions. The spectrum has not free parameters. It’s supposed that the spectrum of harmonic and mixed levels is an exterior spectrum of allowed energy states in relation to a QCD states. The features of the harmonic spectrum, some levels of charm hadrons, the acceptor property of a $c$-quark, the mass rank of quarks and the nature of leptons are discussed.

1 Introduction

In the present publication the harmonic quarks and their complete oscillators are used for decoding mass spectrum of explicitly charmed mesons. In [1, 2] regularity in a spectrum of meson masses was detected and the simple harmonic model of quarks was offered. Furthermore their masses calculated with precision about 0.005%. In the same works it is shown, that the harmonic model and the harmonic quarks are capable to explain experimental masses of some particles, including both a muon, and a neutral pion. Since article [3], we began a systematic application of the harmonic quarks and their complete harmonic oscillators (afterwards also referred to as harmonic oscillators) for exposition of a hadron mass spectrum. In [3] was shown, that the masses of light hadrons up to 1000 MeV are arranged nearly or directly in potential wells of complete harmonic oscillators and their combinations. Here, in this paper, we shall use the same notation, as in [3], namely: standard symbols ($u, s, c$) shall designate the harmonic quarks, while encircled symbols shall designate quarks, which are bound in the complete oscillator or are having the same energy as in oscillator. Besides, a simple and combined potential wells we shall frequently call harmonic levels or simply levels.
In [3] was shown, that there are no light and strange mesons with the mass less than their respective oscillator. In other words, the energy of harmonic oscillator is a lower limit for ground state of hadrons with the given flavor. Thus, mass of $\pi^0$ is greater by 0.7 MeV than oscillator $\bar{u}u$, and mass of $K^\pm$ is greater by 2.3 MeV than oscillator $\bar{s}s$. For mesons with an explicit charm this statement is also valid. The masses of quarks, harmonic oscillators and some mesons with corresponding flavors are given in table 1.

| Quark | Quark mass, MeV | Harmonic oscillator | Oscillator energy, MeV | Meson | Mass of meson, MeV |
|-------|-----------------|---------------------|------------------------|-------|---------------------|
| $d$   | 28.8106         | ($\bar{d}d$)        | 36.683                 | -     | -                   |
| $u$   | 105.441         | ($\bar{u}u$)        | 134.251                | $\pi^0$ | 134.98              |
| $s$   | 385.891         | ($\bar{s}s$)        | 491.332                | $K^\pm$ | 493.65              |
| $c$   | 1412.28         | ($\bar{c}c$)        | 1798.17                | $D^\mu$ | 1864.6              |
| $b$   | 5168.7          | ($\bar{b}b$)        | 6581.0                 | $B_c$ | 6400                |

2 The spectrum of harmonic levels

The mass of the first $c$-hadron $D^0$ is located at 66.4 MeV above an oscillator $\bar{c}c$. We can note that the $c$-quark needs some additional energy for formation of $D^0$, in comparison with the first mesons for $u$- or $s$-flavor (tab.1). At study of a mass spectrum of explicitly charmed mesons we shall not analyze dispersion curves as in [3], but start instead with immediate interpretation of the experimental masses of mesons [4]–[9]. Unlike the light mesons the harmonic oscillator $\bar{c}c$ (i.e. main base level) of the charm mesons has large energy (1798.17 MeV). It considerably facilitates the analysis of their spectrum of masses, since mass differences between the mesons and $\bar{c}c$ oscillator are less than 850 MeV. These differences are given in table 2. The charged mesons of doublets are omitted. The majority of these differences can be explained lightly with use of oscillators ($\bar{s}s$, $\bar{u}u$, $\bar{d}d$) and quark-antiquark pairs ($u\bar{u}$, $s\bar{s}$).

$D^*(2290)^0$, $D_1(2420)^0$ and $D_2(2460)^0$ form a series on the basis of oscillators $\bar{c}c + \bar{s}s$.

$D_2^\pm$, $D^*(2007)^0$ and $D_{s2}(2573)^\pm$ are also arranged in simple potential wells. We can see that this levels is very simple and in the same time it surprisingly exactly agrees with masses of mesons with open charm. In table 2 and fig. are shown the levels which are obtained exclusively from quark-antiquark oscillators with various flavors. There is the unique series of three levels which are formed by consecutive addition of other oscillators to $\bar{c}c$-oscillator:

$\bar{s}s$; $\bar{s}s + \bar{u}u$; $\bar{s}s + \bar{u}u + \bar{d}d$. 

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Thus, this is purely harmonic series. The last level is the total energy of all four complete harmonic oscillators of quarks $c, s, u, d$. These levels are filled by doublets $D^*(2290)^0$, $D_1(2420)$ and $D_2(2460)$.

Table 2. Additional energy of mesons above an oscillator $c\bar{c}$.

| Mesons          | Meson masses, MeV | Additional energy, MeV | Oscillators or quark group | Energy of quark group, MeV |
|-----------------|-------------------|------------------------|----------------------------|---------------------------|
| $D^0$           | 1864.6            | 66.4                   | -                          | -                         |
| $D_s^{\pm}$     | 1968.3            | 170.1                  | $(u\bar{u}) + (d\bar{d})$ | 170.93                    |
| $D^*(2007)^0$   | 2006.7            | 208.5                  | $u\bar{u}$                 | 210.88                    |
| $D_s^{\pm}$     | 2112.1            | 313.9                  | -                          | -                         |
| $D^*(2290)^0$   | 2290              | 491.8                  | $(s\bar{s})$               | 491.3                     |
| $D_{sJ}(2317)^{\pm}$ | 2317.4          | 519.2                  | -                          | -                         |
| $D_1(2420)^0$   | 2422.2            | 624.0                  | $(s\bar{s}) + (u\bar{u})$ | 625.58                    |
| $D_s^*(2460)^0$ | 2458.9            | 661.2                  | $(s\bar{s}) + (u\bar{u}) + (d\bar{d})$ | 662.26 |
| $D_{sJ}(2460)^{\pm}$ | 2459.3          | 661.1                  | $(s\bar{s}) + (u\bar{u}) + (d\bar{d})$ | 662.26 |
| $D_{s1}(2536)^{\pm}$ | 2535.35       | 737.2                  | -                          | -                         |
| $D_{s2}(2573)^{\pm}$ | 2572.4          | 774.2                  | $s\bar{s}$                 | 771.78                    |
| $D^*(2640)^{\pm}$ | 2637             | 838.8                  | -                          | -                         |

Furthermore, the level 2460 generates the strange meson $D_{sJ}(2460)^{\pm}$. Long-lived meson $D^s_1$ is filled also the purely harmonic level from three oscillators $c\bar{c}$, $u\bar{u}$, and $s\bar{s}$. Unlike the level for $D_{sJ}(2460)^{\pm}$, the level for $D^s_1$ does not contain $(s\bar{s})$ oscillator, but it is purely harmonic level and can be included the above named series of levels as its fourth member. In the right part of fig. two hybrid levels are presented. They are formed by excitation of quark - antiquark pairs $u\bar{u}$ and $s\bar{s}$ above the base level $c\bar{c}$. A distinctive feature of these levels is the absence of excited levels with pair $d\bar{d}$.

After this simple procedure there are remained only 5 mesons without interpretation of additional energy:

$D^0, D_{sJ}(2112)^{\pm}$, $D_{sJ}(2317)^{\pm}$, $D_{s1}(2536)^{\pm}$ and $D^*(2640)^{\pm}$.

First of all we shall note that the mass of $D^*(2640)^{\pm}$ is precisely equal to the mass of $D^0$ with the additional excitation $s\bar{s}$. The mass of $D^0$ is greater by 66.4 MeV than a base level. This value is practically equal to the energy of a $u$-quark in its own oscillator $(u\bar{u})$, i.e. half the energy of an oscillator (67.1 MeV). Then, the potential well for $D^0$ can be written as: $(c\bar{c}) + (u\bar{u})$. However the author consider the following form is more right (discussion of this problem will follow): $(c\bar{c}) + 1/2((u\bar{u}) + (d\bar{d})$. Hence the well for $D^*(2640)^{\pm}$ is: $(c\bar{c}) + (s\bar{s}) + 1/2((u\bar{u}) + (d\bar{d})$.

There are only 3 states with a strangeness to be considered. We use the same tactics as for $D^0$. We assume that half energy from an oscillator $(s\bar{s})$ is the energy of the harmonic
bound s-quark (245.7 MeV). We can easily gain levels for $D_s^*(2112)^\pm$ and $D_{s1}(2536)^\pm$:

$\bar{c}\bar{c} + 1/2(\bar{u}\bar{u} + \bar{s}\bar{s})$ and $\bar{c}\bar{c} + 3/2(\bar{s}\bar{s})$

with energies 2111 and 2535 MeV respectively. The potential well for the last particle $D_{sJ}(2317)^\pm$ seems a little debatable: $c + ss + \bar{u}\bar{u}$ with energy of a level 2318 MeV. The level can also be written as: $\bar{c}\bar{c} + s + \bar{u}\bar{u}$. The supposed configuration of level $D_{sJ}(2317)^\pm$ is a little unusual: it contains an odd quark combination in a configuration of the level though a similar combinations are present in configurations of levels $D_{s1}(2536)^\pm$, $D^0$ and $D^*(2640)^\pm$. The results of the full decoding of the meson levels with open charm are presented in table 3 and fig. 1. The dotted line in fig. 1 shows one of the guessed levels. The number of them can be easily increased, but nevertheless these levels are only guessed levels. We are just starting to study both the reasons of their generation and real laws which operate in this area. Model spectrum is calculated from a uniform principle without the free parameters. The standard deviation of charm mesons from their calculated levels is equal to 1.8 MeV. The calculation was made for 16 mesons. The

Figure 1: The complete spectrum of harmonic and mixed levels for mesons with open charm.
four doublets and experimental errors of meson masses give the main contribution in this value. So root-mean-square experimental error for 15 mesons ($D(2290)$ is excluded) is equal to 2.1 MeV.

Table 3. The complete interpretation of meson spectrum with open charm and calculated energy of their levels.

| Mesons          | Meson masses, MeV | Rest of mass above $\bar{c}c$, MeV | Oscillator group or/and quark group | Energy of group, MeV | Calculated energy of level, MeV |
|------------------|-------------------|-------------------------------------|------------------------------------|---------------------|-------------------------------|
| $D^0$            | 1864.6            | 66.4                                | $1/2(\bar{u}u)$                    | 67.1                | 1865.3                        |
| $D_s^\pm(2007)^0$| 2006.7            | 208.5                               | $u\bar{u}$                         | 210.88              | 2009.1                        |
| $D_s^{*\pm}(2290)^0$ | 2112.1          | 313.9                               | $1/2(\bar{s}s) + \bar{s}(s)$      | 312.79              | 2111.0                        |
| $D^*_s(2290)^0$  | 2290              | 491.8                               | $\bar{s}(s)$                       | 491.3               | 2289.5                        |
| $D_{sJ}(2317)^{\pm}$ | 2317.4          | 519.2                               | $s + \bar{s}(\bar{s})$            | 520.14              | 2318.3                        |
| $D_1(2420)^0$    | 2422.2            | 624.0                               | $\bar{s}(s) + \bar{s}(\bar{s})$  | 625.58              | 2423.8                        |
| $D_s^*(2460)^0$  | 2458.9            | 661.2                               | $\bar{s}(s) + (\bar{u}u) + \bar{q}(q)$ | 662.26              | 2460.4                        |
| $D_{sJ}(2460)^{\pm}$ | 2459.3          | 661.1                               | $\bar{s}(s) + (\bar{u}u) + \bar{q}(q)$ | 662.26              | 2460.4                        |
| $D_{s1}(2536)^{\pm}$ | 2535.35         | 737.2                               | $3/2\bar{s}(s)$                    | 737.00              | 2535.2                        |
| $D_{s2}(2573)^{\pm}$ | 2572.4          | 774.2                               | $ss$                               | 771.78              | 2570.0                        |
| $D^*(2640)^{\pm}$ | 2637              | 838.8                               | $ss + 1/2(\bar{s}(\bar{s})$       | 838.91              | 2637.1                        |

3 DISCUSSION OF RESULTS

Simple, logical, complete and precise interpretation of mass spectrum of mesons with open charm demonstrates to us that harmonic quarks are a new true message from a microcosm. At present the particle physics has not other quantitative theory or a model which achieve such exact results. Now the question - To be or not to be? - in relation of the harmonic quarks can be closed. They exist and their rest masses are calculated precisely enough. Actually there are another problems. How should the harmonic quarks be integrated correctly with QCD and Standard Model?

How may we create field theory in which the mass ratio of neighboring quarks is a constant equal to $\pi/(4 - \pi)$ and which has a solution with the bound harmonic states of the quark-antiquark pairs? What should a boundary conditions be at low and high energies to restrict a theoretical quark spectrum to only really observable quarks? Why are the complete harmonic oscillators so important for hadronic physics?
3.1 Some features of model spectrum

Returning to the subject of the paper, we should note one important observed fact. It is necessary to distinguish quark interpretation of harmonic level and an actual quark composition of a hadron on this level. It is especially important in regard to long-lived particles. The simple example is any multiplet which fills only one harmonic level. *The harmonic levels are indifferent to an isospin.* So, for each pair of mesons $K^{*\pm}$ and $K^{*0}$ or $D^0$ and $D^\pm$ there is the harmonic level which has the position between a mesons of doublet. Energy of level corresponds to centre of potential well as it is shown in fig. 2. The multiplets can occupy various positions in these wells.

![Figure 2: The scheme of harmonic wells and arrangement of hadron doublets.](image)

For example, pions and kaons have a little shift from centre in side of energy increase. These effects can be considered in detail in tables of this work and [1, 2, 3]. It is necessary to notice, a mesons with different secondary flavor, for example $D^*_2(2460)$ and $D_{s1}(2460)^\pm$, can be arranged on one harmonic level. *Probably, the harmonic levels are also not sensitive to secondary flavor.*

In table 4 the most important potential wells are given for 4 flavors and there are the hadrons which perhaps connected with these wells. The all levels of a charmed meson spectrum contains the ground oscillator - $\circ\circ$. Depth of a potential well of an oscillator is proportional to its mass. For $\circ\circ$ the depth of the well is 1026 MeV, if it is counted from a rest energy of quark-antiquark $c$-pair. It is logical to assume, that the potential well of an oscillator is capable to keep more light quarks and oscillators. $\circ\circ$-well is enough deep and it is capable to keep $d$, $u$- and $s$-quarks as well as their oscillators. It actually confirms the obtained spectrum, especially a series of harmonic levels. In table 4, besides a series on the basis of $\circ\circ$, we can observe other series. They are built on deep wells from the combinations of multiple $s$-oscillator: $2(\circ\circ\circ)$ and $3(\circ\circ\circ)$. We can see...
that the harmonic wells can be occupied not only by mesons, but also baryons. Thus we come to the conclusion, that probably, the harmonic potential wells are also not sensitive to type of a hadron. They can be a manifestation of the more common rules and they determine energy spectrum of all hadrons. On fig. 3 the mass spectrum of charm baryons is added to the data obtained in this work. It is obvious that the lightest baryons ($\Lambda^+_c$, $\Sigma^+_c$, $\Xi^+_c$) are also close to the found harmonic levels.

Hence, the spectrum of harmonic levels (at least for the charmed mesons) may be determined as the spectrum of allowed states. There is an initial underrstanding that hadronic states of a QCD are limited by energy spectrum of harmonic levels. The hadronic states are perhaps forced to the nearest harmonic potential wells or mixed wells.

Table 4. The most important potential wells from complete harmonic oscillators of quarks: $d, u, s, c$.

| Harmonic potential wells | The total energy of well oscillators, MeV | Hadron mass, MeV | Hadron |
|--------------------------|------------------------------------------|-----------------|--------|
| ($u\bar{u}$)            | 134.25                                   | 134.98          | $\pi^0$ |
| ($s\bar{s}$)            | 491.33                                   | 493.65          | $K^\pm$ |
| ($s\bar{s}$) + ($u\bar{u}$) | 625.6                                   | -               | -      |
| 3($s\bar{s}$) + 3($u\bar{u}$) | 938.37                                   | 938.27          | $p, \bar{p}$ |
| 2($s\bar{u}$)           | 982.66                                   | 984.8           | $a_0(980)$ |
| 2($s\bar{u}$) + ($d\bar{d}$) | 1116.9                                   | 1115.7          | $f_0(980)$ |
| 2($s\bar{s}$) + 3($u\bar{u}$) | 1385.4                                   | 1383.7          | $\Sigma(1385)$ |
| 3($s\bar{s}$)           | 1474.0                                   | 1474            | $a_0(1450)$ |
| 3($s\bar{s}$) + ($d\bar{d}$) | 1510.7                                   | 1507            | $f_0(1500)$ |
| 3($s\bar{s}$) + ($u\bar{u}$) | 1608.2                                   | 1600            | $\Lambda(1600)$ |
| 3($s\bar{s}$) + 3($u\bar{u}$) | 1876.8                                   | 1876.7          | $\eta(1475)$ |
| 3($s\bar{u}$) + $1/2$($u\bar{u}$) | 1865.3                                   | 1864.6          | $\rho(1450)$ |
| ($c\bar{c}$) + ($u\bar{u}$) + ($d\bar{d}$) | 1969.1                                   | 1968.3          | $D^0$ |
| ($c\bar{c}$) + ($s\bar{s}$) | 2289.5                                   | 2290            | 2290   |
| ($c\bar{c}$) + ($s\bar{u}$) + ($d\bar{d}$) | 2423.8                                   | 2422.2          | 2422.2 |
| ($c\bar{c}$) + 3($s\bar{s}$) + ($u\bar{u}$) + ($d\bar{d}$) | 2460.4                                   | 2458.9          | 2459.3 |

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3.2 A feature levels

Let’s now to discuss an individual features of some levels. The spectrum has a potential wells with an odd number of quarks:

- $\bar{c}c + 1/2(\bar{s}s)$ for $D^0$ and $D^\pm$;
- $\bar{c}c + \bar{u}u + s$ for $D_{sJ}(2317)^\pm$;
- $\bar{c}c + 3/2(\bar{s}s)$ for $D_{s1}(2536)^\pm$;
- $\bar{c}c + ss + 1/2(\bar{u}u)$ for $D^*(2640)^\pm$.

The simplest variant for an explanation of this phenomenon can be some pair solutions for particles and antiparticles, for example, as the similar solution for a pair $e^+e^-$. This pair solution, i.e. doubling, ensures us even configurations. So, level $D^0\bar{D}^0$ may be written as: $2(\bar{c}\bar{c}) + \bar{u}u$. This configuration is completely similar to configuration of $\phi(1019)$ in tab.4. They are differed from each other only by shift on one step on a quark scale. However, this shift changes a situation, since energy and a numbers of quarks with charges $\pm 1/3e$ and $\pm 2/3e$ are different. The quarks with a charge $\pm 1/3e$ for $\phi$-level are completely replaced with the quarks with a charge $\pm 2/3e$. We have not the complete
physical analogy of two levels and therefore the different ending is possible: level $\phi$ keeps up whereas level $D^0 \bar{D}^0$ breaks up.

The decay of the unique level $6c + 6\bar{u}$ on $p\bar{p}$ is also given in table 4.

Other explanation for a level $c\bar{c} + 1/2(u\bar{u})$ can be proposed with the absence of a level $c\bar{c} + u\bar{u}$. Perhaps, it is forbidden for still unknown reasons. The basic level $c\bar{c}$ is also forbidden. The level $c\bar{c} + 1/2(u\bar{u})$ is arranged in the middle between forbidden levels, and it is probably a degenerate level.

### 3.3 The mass rank of quarks

We have two levels which contain a half $u$-oscillator $1/2(u\bar{u})$, i.e. harmoniously bound $u$-quark, similar to $u$-quarks in a neutral pion. A pion in $u\bar{u}$-phase (this restriction follow of a QCD with its a superposition of states $u\bar{u}$ and $d\bar{d}$) is practically pure harmonic state of a bound $u\bar{u}$-pair. It is the lowermost level in a spectrum of hadrons and only therefore it is unique. It is a single long-lived meson and a truly neutral particle is directly arranged in a potential well $u\bar{u}$. There is not any other truly neutral particle, which is arranged in potential well of kind $q\bar{q}$. So, $K^0$ has an antiparticle with an antiquark composition. In a state of $u$-quarks the pion can be written down as: $\pi^0$, where $\pi$ is a bound $u$-quark with the rest mass equal to $1/2$ of energy of a $u$-oscillator, i.e. 67.1257 MeV. Then the dynamic energy of $\pi$-quarks in pion is $m_{\pi^0} - 134.2514$ and equal to 0.7252 MeV. Together with a Coulomb electrostatic energy of $\pi$-quark pair it will correspond to the kinetic energy of $\pi$-quarks on small distances, where the color energy is small enough. Accepting this structure of $\pi^0$, we actually assume, that the rest mass of a quark in harmonic bound state decreases in $\pi/2$ times.

This phenomenon possible to name as diminution of the mass rank of quark (DMRQ).

In essence, all levels (potential wells) on fig. 1 are obliged by their existence to DMRQ. Even the levels for particles $D^*(2007)^0$ and $D_{s2}(2573)^\pm$ are constructed on basis of $c$-quarks with DMRQ. We can see that light quarks can decrease their mass rank in the strong field of a heavy quark or its oscillator. We can even note, a quarks in state DMRQ of first order can again form a harmonic oscillator with the further decrease of mass. There may to occur a secondary DMRQ (see a level for $D^*_s(2112)^\pm$).

In the same time the spectrum contain levels with odd number of $\pi$ quarks. However the majority of levels consist from neutral groups with even number of quarks. Hence for $u$-quark we can suppose an existence of his neutral state of kind $u^0$ and $\bar{u}^0$. It is possible to assume that the charge $2/3e$ of $u$-quark may be not elementary in comparing with $1/3e$ of other quarks. Then a $u$-quark contains two elementary charges. Therefore it is possible to imagine the reaction of a part annihilation of $u\bar{u}$ pair which goes to formation of $u_0$, and even to $\bar{u}^0$ in a field of a heavy quark in result of DMRQ.
3.4 Acceptor property of $c$-quark

The levels $c\bar{c} + 1/2(\bar{u}u)$ and $c\bar{c} + u\bar{u}$ are allowed. There is an electromagnetic transition between mesons of these levels. The quark reaction of transition from the first level to second level can be written as follows:

$$u + \bar{u} = (u/2 + u/2) + (\bar{u}/2 + \bar{u}/2) \Rightarrow 1/2(\bar{u}u) = \bar{n}^0.$$

In this reaction we assume that $u$-quark consists from two parts with charges equal $1/3e$ as well as any other quark with a charge $2/3e$. It is supposed, that the powerful field of an oscillator $c\bar{c}$ promotes this reaction, i.e. a level $c\bar{c} + 1/2(\bar{u}u)$, can be written as: $(c + \bar{u}/2) + (\bar{c} + u/2)$. The last record could mean that the $c$-quark has very unsaturated internal structure, and it is capable to accept an additional energy. A $c$-quark is an acceptor. A $b$-quark is a donor.

A $c$-quark has a certain acceptor properties. Only the spectrum of $b$-hadrons is arranged below $b\bar{b}$-oscillator. The mass of $b^\pm$ is only greater by 5 MeV than total mass of $u$- and $b$-quarks, and is 1302 MeV less than $b\bar{b}$-oscillator. The mass of a $D^0$ is greater by 344 MeV than the total mass of $u$- and $c$-quarks and it is greater by 66.4 MeV than $c\bar{c}$-oscillator. If the tendency fulfilled for a $b$-quark, the additional energy (energy over masses of $u$- and $b$-quarks) would be about 1306 MeV. However, for existence of a $b$-meson an additional energy is not required, i.e. the $b$-quark is not an acceptor. On the contrary, the heavy $b$-quark, being the owner of a large potential energy, can even have donor properties. So, the mass of $B_s$ is less than the total mass of $s$- and $b$-quarks. It is possible that the nature of acceptor or donor properties of quarks is connected with difference of internal structure of quarks. This difference is reflected in their charges ($1/3e$ or $2/3e$). Quarks with the charge $1/3e$ is perhaps more simple objects. Besides it is natural that this distinction of energy properties are more clearly expressed at heavy quarks. We shall return to this problem, but at present time it is enough to formulate the presence of a problem.

3.5 The $\tau$-lepton

The mass of $\tau$-lepton is 1777 MeV. It is only 21 MeV less than the mass of $c\bar{c}$-oscillator, but this also means, that birth of meson with a rest mass less than $c\bar{c}$-oscillator is forbidden. In [2] we assumed, that if the muon is formed on the mass basis of the $u$-quark then the $\tau$-lepton may be also formed on the mass basis of the $c$-quark. A creation of leptons is accompanied by inhibition or annihilation of color charge and by increase of electrical charge by $1/3e$. It is important to note that masses of both leptons are only on 20-30 MeV less than the masses of corresponding harmonic oscillators (see fig. 4).

The harmonic oscillators on fig. 4 are located on zero line.
The other validity of this important assumption proves the fact of approximate equal lifetimes of quarks and corresponding leptons. So, the lifetime of $\tau$-lepton is $3 \times 10^{-13}$ sec. This value is practically the same as the lifetimes of $D^0$ and $D^\pm$ mesons. Lifetime of these mesons is defined by the lifetime of a $c$-quark. Besides, both leptons are formed on a mass basis of quarks with a charge $2/3e$. If it is quite clearly for muon (the masses of muon and $u$-quark are practically equal, even the distinction of masses in 0.2 MeV has quite clear interpretation [1, 2]), for $\tau$-lepton such obviousness is absent. However the author believes that all is true, therefore it also illustrates an acceptor properties of $c$-quark.

4 Conclusion

- The precise model spectrum of mesons with open charm is formed exclusively on rest masses of the harmonic quarks and their complete oscillators. The spectrum has not free parameters. It is calculated exclusively with use of hard harmonic quark model.
• It is assumed the harmonic spectrum is an allowed energetic states in relation to a QCD states.

• The harmonic quarks and their complete oscillators are actual objects of a microcosm.

• A rest masses of the harmonic quarks are calculated with the declared precision $\sim 0.005\%$.

• The harmonic quarks can decrease their mass rank at certain conditions.

• The complete harmonic oscillators are the basis of the strong coupling and physics of hadrons.

• The $c$-quark has acceptor properties.

• It is obtained additional arguments in support of assumption that the $\tau$-leptons are formed with use of $c$-quarks.

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