

MMCP

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D–, D_s–resonances electroweak characteristics in a relativistic quark model employing analytical computing systems calculation

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Introduction

The volume of modern high-precision experimental data for light mesons has stimulated the development of phenomenological models and approaches. For heavy mesons, the decay mechanisms are more complex, or the of high-precision data content is smaller.

The authors presents a method for D^{*0}–, D^{0}– and $D_s^{*\pm}$–, $D_s^{\pm}$– heavy mesons mass calcualtion in a model, based on the composite quark model and the point form of the Poincaré-invariant quantum mechanics (further PiQM). The authors demonstrates that usage model parameters obtained from light sector meson decays and eigeneigenvalue 3×3–case calculation leads to good agreement for mass of D^{*0}–, D^{0}– and D_s^{*}–, D_s^{0}–higher states compare with experimental data. As a result of work, the radiative decay form-factors values taking into account constituent quark magnetic moment were assessed.

The aim of the work is

developing a method for D^{*0}–, D^0– and D_s^*–, D_s– heavy mesons masses and form-factors calculation using analytical computing systems calculation [1].

Outline of presentation:

- summary of the key relationships of the model under development, based on the point form of PiQM;
- eigenvalues of the hamiltonian calculation consist kinetic terms and quark-antiquark potential terms with analytical expressions for matrix elements;
- mass values estimation for D^{*0}–, D^0– and D_s^*–, D_s– heavy meson and their radiative decay constants.

[1] Wolfram Mathematica 14.3

Model description

State vector of meson with 4-momentum $Q^\mu = \{\omega_M(\mathbf{Q}), \mathbf{Q}\}$, mass M ($Q^2 = M^2$), spin J in point form of PiQM determined by the integral over the relative momentum $\mathbf{k}$ of quarks with masses m_q, $m_{\bar{Q}}$ and momentums $\mathbf{p}_{1,2}$ respectively as [2]

$$|\mathbf{Q}, J\mu, M\rangle = \sum_{\lambda_1,\lambda_2}\sum_{\nu_1,\nu_2}\int \mathbf{dk}\,\Phi^{J\mu}_{\ell S}(\mathbf{k},\,\beta_{q\bar{Q}})\Omega\left(\begin{smallmatrix}\ell & S & J\\ \nu_1 & \nu_2 & \mu\end{smallmatrix}\right)(\theta_k,\phi_k)\times \quad (1)$$

$$\times\sqrt{\frac{\omega_{m_q}(\mathbf{p}_1)\omega_{m_{\bar{Q}}}(\mathbf{p}_2)}{\omega_{m_q}(\mathbf{k})\omega_{m_{\bar{Q}}}(\mathbf{k})\mathbb{V}_0}}\,D^{1/2}_{\lambda_1,\nu_1}(\mathbf{n}_{W_1})\,D^{1/2}_{\lambda_2,\nu_2}(\mathbf{n}_{W_2})\,|\mathbf{p}_1,\lambda_1,\mathbf{p}_2,\lambda_2\rangle\,.$$

In (1) for brevity the notations are used

$$\mathbb{V}_0 = \omega_{M_0}(\mathbf{Q})/M_0,\ \omega_m(\mathbf{Q}) = \sqrt{\mathbf{Q}^2+m^2}, \quad (2)$$

$$\Omega\left(\begin{smallmatrix}\ell & S & J\\ \nu_1 & \nu_2 & \mu\end{smallmatrix}\right)(\theta_k,\phi_k) = Y_{\ell m}(\theta_k,\phi_k)\;C\left(\begin{smallmatrix}s_1 & s_2 & S\\ \nu_1 & \nu_2 & \mu\end{smallmatrix}\right)C\left(\begin{smallmatrix}\ell & S & J\\ m & \lambda & \mu\end{smallmatrix}\right),$$

[2] Keister, B. D. Relativistic Hamiltonian dynamics in nuclear and particle physics/ B. D. Keister, W. N. Polyzou // Adv. Nucl. Phys.–1991. – Vol. 20. – P. 225–479.

Model description

where $Y_{\ell m}(\theta_k, \phi_k)$ is spherical functions defined by the angles of the $\mathbf{k}$ – vector , $D^{1/2}_{\lambda,\nu}(\mathbf{n}_W)$ are Wigner rotation functions and $M_0 = \omega_{m_q}(\mathbf{k}) + \omega_{m_{\bar{Q}}}(\mathbf{k})$ – invariant mass of constituent quarks. The wave function in (1) is normalized by the condition

$$\sum_{\ell,S} \int \mathrm{dk}\, \mathrm{k}^2 \left| \Phi^{J\mu}_{\ell S}(\mathbf{k},\ \beta_{q\bar{Q}}) \right|^2 = 1. \tag{3}$$

Using the parametrization of vector meson leptonic $V(q\bar{q}) \to \ell^+\ell^-$ decay

$$\langle 0 \left| \hat{J}^{\mu}_V(0) \right| \mathbf{Q}, 1\lambda_V, M_V \rangle = \frac{\mathrm{i}}{(2\pi)^{3/2}} \frac{\varepsilon^{\mu}(\lambda_V)}{\sqrt{2\omega_{M_V}(\mathrm{P})}} M_V f_V \tag{4}$$

and quark current taking into account its electromagnetic structure

$$\langle 0 \left| \hat{J}^{\mu}_V(0) \right| \mathbf{k}, \lambda_1, -\mathbf{k}, \lambda_2 \rangle = \frac{1}{(2\pi)^3} \frac{\bar{v}_{\lambda_2}(-\mathbf{k}, m_q) \Gamma^{\mu} u_{\lambda_1}(\mathbf{k}, m_q)}{\sqrt{4\, \omega_{m_q}(\mathrm{k})\, \omega_{m_q}(\mathrm{k})}} \tag{5}$$

Model description

where [3]

$$\Gamma_q^{\mu} = e_q \gamma^{\mu} + e_q \frac{\kappa_q}{2\, m_q}\, i\, \sigma^{\mu\nu}\, q_{\nu}^{tr.}, \tag{6}$$

($q_{\nu}^{tr.}$ is the vertex quark transferred momentum) one can obtain

$$f_V(e_q, \kappa_q, m_q, \beta_{q\bar{q}}^V) = \frac{\sqrt{3}}{\pi} \int_0^{\infty} \mathrm{dk}\, \mathrm{k}^2\, \Phi(\mathrm{k}, \beta_{q\bar{q}}^V) \times \tag{7}$$

$$e_q \left(\frac{m_q + 2\,\omega_{m_q}(\mathrm{k})}{3\,\omega_{m_q}^{3/2}(\mathrm{k})} + \frac{\kappa_q}{2\, m_q} \frac{2\left(\omega_{m_q}^2(\mathrm{k}) + 2\, m_q\, \omega_{m_q}(\mathrm{k})\right)}{3\,\omega_{m_q}^{3/2}(\mathrm{k})} \right).$$

In relation (7) used notation for anomalous magnetic moment κ_q which determines the total magnetic moment of the constituent quark as

$$\mu_q = \frac{e_q}{2\, m_q}(1 + \kappa_q). \tag{8}$$

[3] Krutov, A. F. Magnetic moment of the ρ–meson in instant-form relativistic quantum mechanics/ A. F. Krutov, R. G. Polezhaev, V. E. Troitsky // Phys. Rev. D.–2018. – Vol. 97. – P. 033007.

Variational method for eigenvalue problem

The heavy D^{*0}–, D^0– and D_s^*–, D_s– heavy mesons masses and their radial excitations calculation we will carry out using the eigenvalue problem

$$\hat{H}_{q\bar{Q}} |\psi\rangle = \left(\hat{T}_q + \hat{T}_{\bar{Q}} + \hat{V}_{q\bar{Q}}(\mathrm{r})\right) |\psi\rangle = M |\psi\rangle, \tag{9}$$

where $\hat{T}$ is kinetic energy operator which defined in $\mathbf{k}$ – space as

$$\hat{T}_q = \sqrt{\mathbf{k}^2 + m_q^2}, \;\; \hat{T}_{\bar{Q}} = \sqrt{\mathbf{k}^2 + m_{\bar{Q}}^2}, \tag{10}$$

and M is eigenvalue (meson mass) of the Hamiltonian $\hat{H}_{q\bar{q}}$. Note that the quark-antiquark potential $\hat{V}_{q\bar{q}}(\mathrm{r})$ in the proposed defined as sum of the Coulomb, linear and spin-spin parts

$$\hat{V}_{q\bar{Q}}(\mathrm{r}) = \hat{V}_{\text{coul.}}(\mathrm{r}) + \hat{V}_{\text{linear}}(\mathrm{r}) + \hat{V}_{S\bar{S}}(\mathrm{r}), \tag{11}$$

which after the smearing procedure in $\mathbf{r}$–space will take the following form:

Variational method for eigenvalue problem

$$\hat{V}_{\text{coul.}}(\mathrm{r}) = -\frac{4}{3\,\mathrm{r}}\sum_{i=1}^{7}\alpha_i\,\mathrm{erf}\left(\tau_i(b)\,\mathrm{r}\right), \quad \tau_i(b) = \frac{b\,\gamma_i}{b^2+\gamma_i^2}\ {}^{4,5,6}, \quad (12)$$

$$\hat{V}_{\text{linear}}(\mathrm{r}) = \sigma\,\mathrm{r}\left(\frac{1}{\sqrt{\pi}}\,\frac{\exp\left[-b^2\,\mathrm{r}^2\right]}{b\,\mathrm{r}} + \left(1+\frac{1}{2\,b^2\,\mathrm{r}^2}\right)\,\mathrm{erf}(b\,\mathrm{r})\right) + w_0, \quad (13)$$

$$\hat{V}_{S\bar{S}}(\mathrm{r}) = -\frac{32\,\left(\mathbf{S}_q\cdot\mathbf{S}_{\bar{Q}}\right)}{9\,\sqrt{\pi}\,m_q\,m_{\bar{Q}}}\,\sum_{i=1}^{7}\tau_i^3(b)\,\exp\left[-\tau_i^2(b)\,\mathrm{r}^2\right] \quad (14)$$

(in (12),(13),(14) α_i and γ_i is set of phenomenological parameters). Potential (11) with expressions (12)-(14) and value $\alpha_{crit.} \simeq 0.66$ will be used for developed model parameters calculation.

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[4] Godfrey, S. Mesons in a relativized quark model with chromodynamics/ S. Godfrey, N. Isgur // Phys. Rev.–1985. – Vol. D32. – P. 189–231.

[5] Deur, A. The QCD running coupling/ A. Deur, S.J. Brodsky, F. Guy // Nucl. Phys.–2016. – Vol. 90. – 74 P.

[6] Voloshin, M. B. Charmonium/ M. B. Voloshin // Prog. Part. Nucl. Phys.–2008. – Vol. 61. – P. 455–511.

Variational method for eigenvalue problem

The eigenvalue problem solution

$$\hat{H}_{q\bar{Q}} \, |\psi\rangle = M \, |\psi\rangle \tag{15}$$

we will carry out using the basis of orthonormal functions ϕ_i. Decomposition $|\psi\rangle = \frac{1}{\sqrt{N}} \sum_{i=1}^{3} c_i \, |\phi_i\rangle$ for (15) leads to

$$\left(H_{q\bar{Q}}\right)_{j\,i} \, c_i = M \, c_j, \;\; \langle \phi_j \, | \phi_i \rangle = \delta_{j\,i}, \tag{16}$$

where c_j is eigenvector of Hamiltonian $\hat{H}_{q\bar{Q}}$. Note that trial wave functions in **k**–space is chosen in the form

$$\Phi^{(\mathrm{osc.})}_{n\,\ell}(\mathrm{k}, \beta) = \tag{17}$$

$$= (-1)^n (-i)^\ell \sqrt{\frac{2\,\Gamma(1+n)}{\Gamma(\frac{3}{2}+\ell+n)}} \, \exp[-\frac{\mathrm{k}^2}{2\,\beta^2}] \, \left(\frac{\mathrm{k}}{\beta}\right)^\ell \, L_n^{\ell+\frac{1}{2}}\left(\frac{\mathrm{k}^2}{\beta^2}\right),$$

with Euler's Gamma Function $\Gamma(n)$ and generalized Laguerre polynomials $L_a^b(x)$.

Variational method for eigenvalue problem

Eigenvalue (16) problem solving will be conducted using analytical computing systems calculation [7]:

$$\text{Eigenvalues}\left[\begin{pmatrix} h(0,0) & h(0,1) & h(0,2) \\ h(1,0) & h(1,1) & h(1,2) \\ h(2,0) & h(2,1) & h(2,2) \end{pmatrix}, \text{Cubics} \to \text{True}\right] \tag{18}$$

where h is a symbol for a matrix element (16) and "Cubics $\to$ True" command allows explicit forms for solutions to cubic equations.

The explicit form of the expression for the eigenvalues (18) is rather cumbersome, so it will not be shown below. Note that computing systems calculation also allows eigenvector calculation by "Eigenvectors" build-in operand.

[7] Wolfram Mathematica 14.3

Numerical results

Numerical calculation for masses D^{*0}–, D^{0}– and D_s^{*}–, D_s– heavy mesons will be conducted with two sets of parameters. Firs set

$$m_c = (1683.45 \pm 4.45)\ \text{MeV}, \tag{19}$$

$$\beta^P_{c\bar{d}} = (500.41 \pm 3.11)\ \text{MeV},\ \beta^V_{c\bar{d}} = (485.14 \pm 4.43)\ \text{MeV},$$

$$\beta^P_{c\bar{u}} = (470.61 \pm 4.52)\ \text{MeV}, \beta^V_{c\bar{u}} = (479.90 \pm 4.74)\ \text{MeV}.$$

and

$$m_u = (217.15 \pm 4.39)\ \text{MeV},\ m_d = (219.69 \pm 4.39)\ \text{MeV} \tag{20}$$

$$\kappa_c = 0.192 \pm 0.073,\ \ \mu_c = \frac{e_c}{2\,m_c}(1+\kappa_c) = (0.44 \pm 0.04)\ \mu_N.$$

is obtained from radiative and leptonic decays of light $\pi^{\pm}$–,$\rho^{\pm}$– and heavy $D^{*\pm}$–, $D^{\pm}$– mesons [8].

[8] Haurysh, V. Yu., Andreev, V. V. Constituent quark masses in Poincare-invariant quantum mechanics/ V. Yu. Haurysh, V. V. Andreev, V. V. // J.Phys.Conf.Ser.–2017. – Vol. 938. – P. 012030.

Numerical results

Using the model parameters and eigenvalues (18) yields the following values for the masses of neutral pseudoscalar ($\left(\mathbf{S}_q \cdot \mathbf{S}_{\bar{Q}}\right) = 3/4$) D^0– and vector ($\left(\mathbf{S}_q \cdot \mathbf{S}_{\bar{Q}}\right) = 1/4$) D^{*0}–mesons:

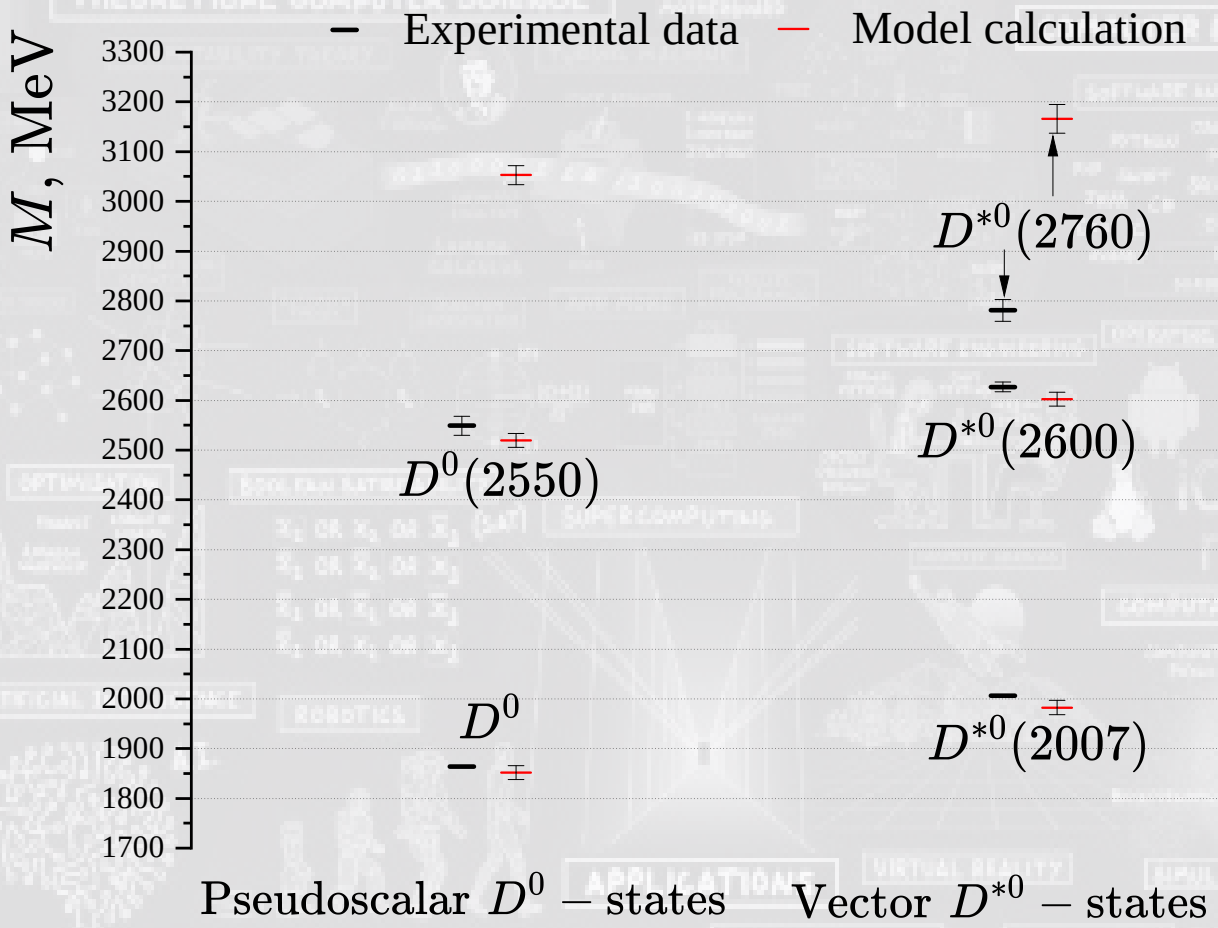

Figure: Comparison of pseudoscalar D^0– and vector D^{*0}–mesons masses with experimental data

Numerical results

Similarly, using $m_s = (411.29 \pm 4.34)$ MeV [9] and β_{cs}–parameters for D_s^*–, D_s– heavy mesons one can get:

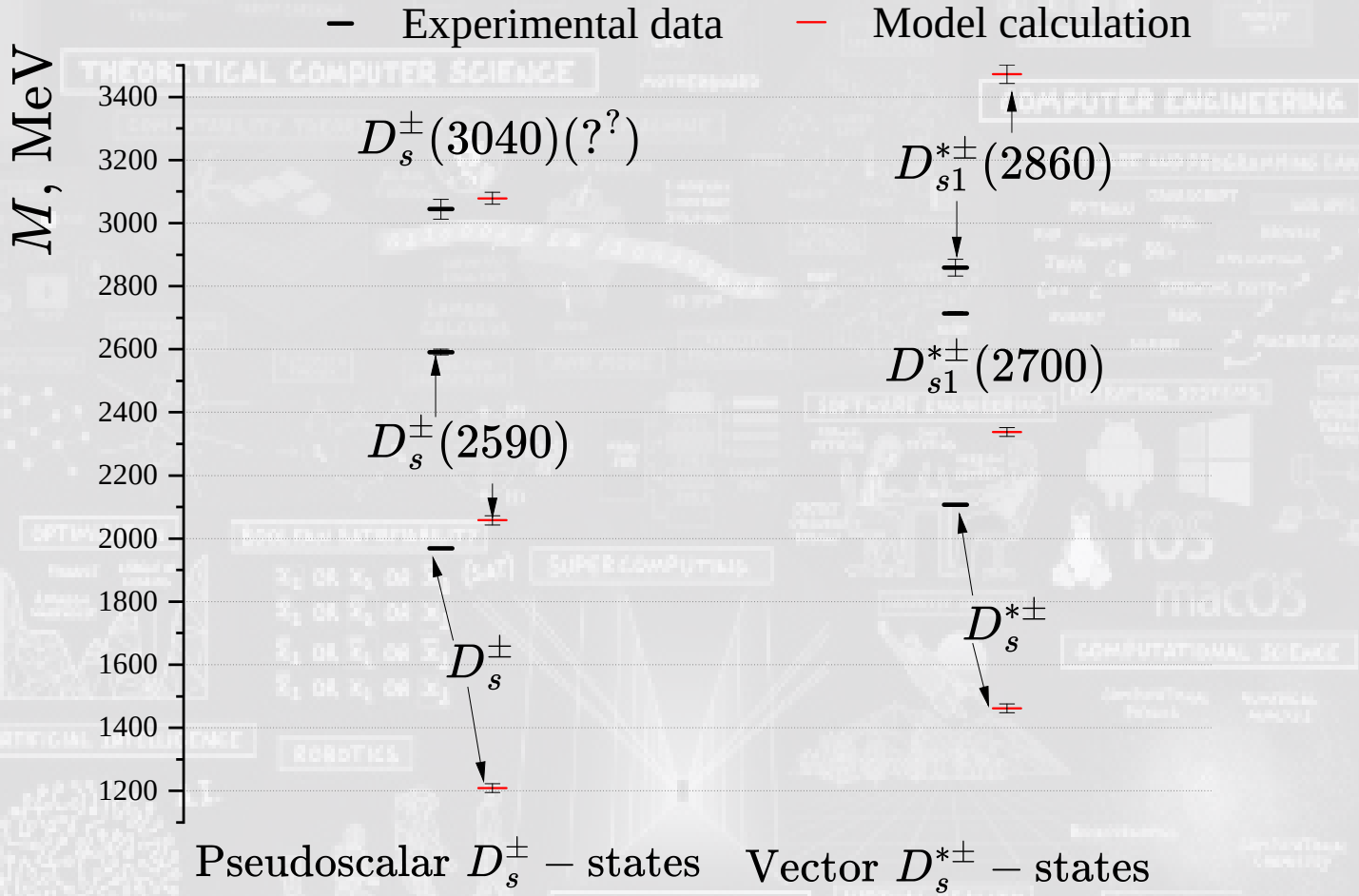

Figure: Comparison of pseudoscalar $D_s^{\pm}$– and vector $D_s^{*\pm}$–mesons masses with experimental data

[9] Haurysh, V. Yu., Andreev, V. V. Constituent quark masses in Poincare-invariant quantum mechanics/ V. Yu. Haurysh, V. V. Andreev, V. V. // J.Phys.Conf.Ser.–2017. – Vol. 938. – P. 012030.

Numerical results

An analysis of the figures shows that, using the proposed approach, it is possible to select more optimal model parameters. Minimum calculation using analytical computing systems [10]

$$\chi^2_{d.o.f} = \frac{\left(M_{D^0} - M_1(m_c, \beta^P_{u\bar{c}})\right)^2}{\left(\delta M_{D^0}\right)^2} + \frac{\left(M_{D^0(2550)} - M_2(m_c, \beta^P_{u\bar{c}})\right)^2}{\left(\delta M_{D^0(2550)}\right)^2} + \frac{\left(M_{D^{*0}(2007)} - M_1(m_c, \beta^V_{u\bar{c}})\right)^2}{\left(\delta M_{D^0(2007)}\right)^2} + \frac{\left(M_{D^{*0}(2600)} - M_2(m_c, \beta^V_{u\bar{c}})\right)^2}{\left(\delta M_{D^{*0}(2600)}\right)^2} + \frac{\left(M_{D^{*0}(2760)} - M_3(m_c, \beta^V_{u\bar{c}})\right)^2}{\left(\delta M_{D^{*0}(2760)}\right)^2} \tag{21}$$

where functions $M_i(m_c, \beta_{cq})$ are eigenvalues of (18)

[10] Wolfram Mathematica 14.3

Numerical results

leads to

$$m_c = (1389.43 \pm 6.42)\ \text{MeV}, \tag{22}$$
$$\beta^P_{c\bar{u}} = (473.25 \pm 4.52)\ \text{MeV}, \beta^V_{c\bar{u}} = (363.79 \pm 7.24)\ \text{MeV}.$$

Values (22) leads to following masses of D^{*0}–, D^0–mesons:

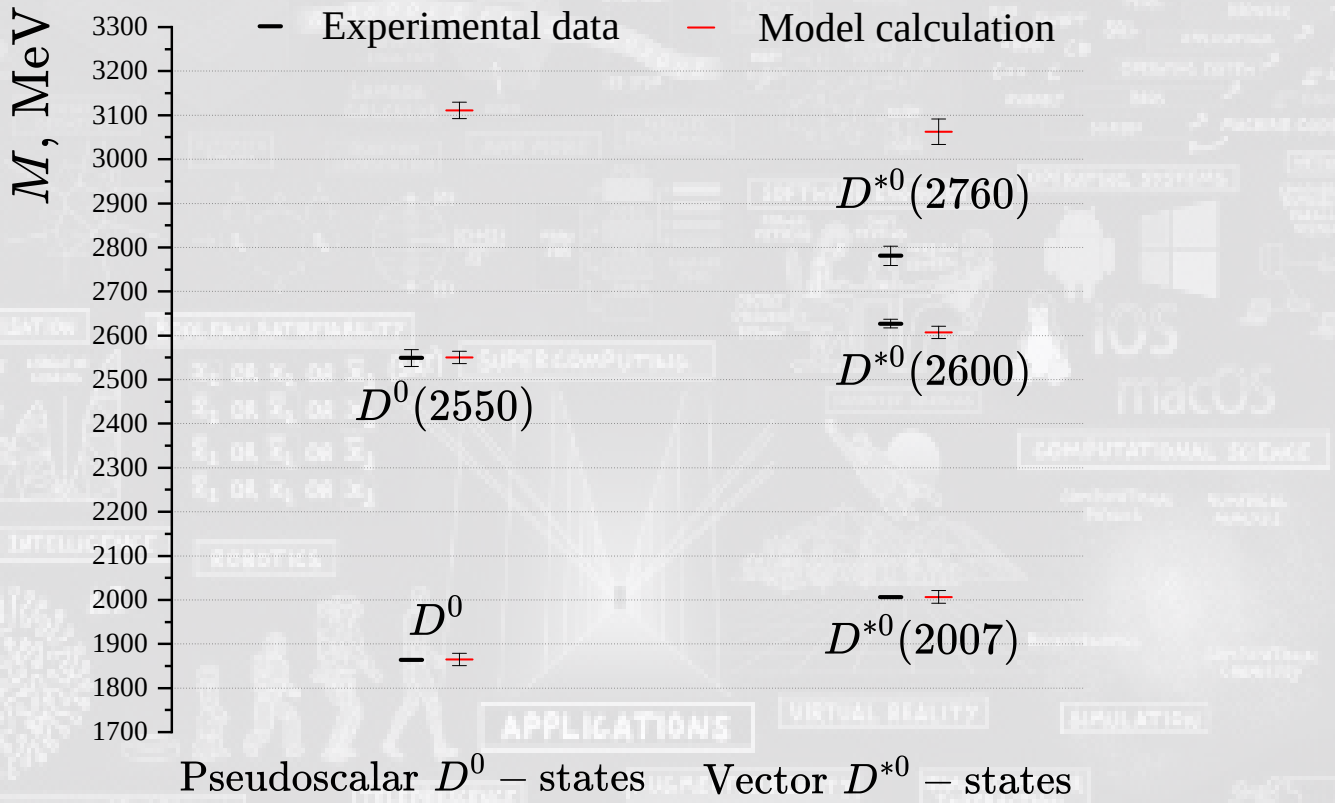

Figure: Comparison of pseudoscalar D^0– and vector D^{*0}–mesons masses with experimental data

Numerical results

A similar procedure for calculating the minimum of the functional via (22) yields the following values

$$\beta^P_{c\bar{s}} = (532.19 \pm 7.52)\ \text{MeV}, \beta^V_{c\bar{s}} = (379.01 \pm 5.73)\ \text{MeV}. \quad (23)$$

Values (23) leads to following masses of D_s^{*0}–, D_s^0–mesons:

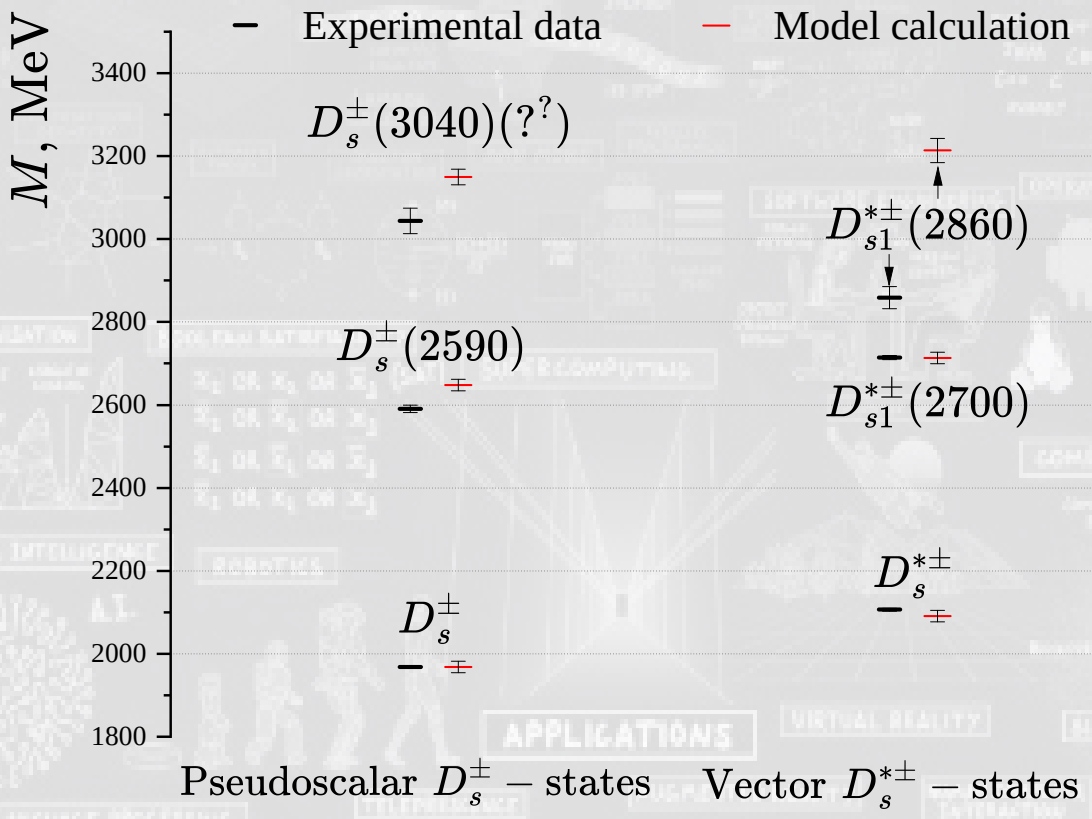

Figure: Comparison of pseudoscalar D_s^0– and vector D_s^{*0}–mesons masses with experimental data

Electroweak characteristic calculation

Using obtained parameters one can predict certain quantities that have not yet been measured experimentally. We focus on radiative decays $V(P) \to P(V)\gamma$ since such decay processes occur through well-understood mechanisms. In the proposed approach, the integral representation of the radiation decay constant is given by the expression [11]:

$$g_{VP\gamma} = \frac{1}{\sqrt{M_V M_P}} \int \mathrm{dk}\, \mathrm{k}^2\, \Phi(\mathrm{k}, \beta^V_{q\bar{Q}}) \Phi(\mathrm{k}, \beta^P_{q\bar{Q}}) \left(e_q f_1(\mathrm{k}, m_q, m_{\bar{Q}}) - \right. \tag{24}$$

$$\left. + \frac{e_q \kappa_q}{2m_q} f_2(\mathrm{k}, m_q, m_{\bar{Q}}) - e_{\bar{Q}} f_1(\mathrm{k}, m_{\bar{Q}}, m_q) - \frac{e_{\bar{Q}} \kappa_{\bar{Q}}}{2m_{\bar{Q}}} f_2(k, m_{\bar{Q}}, m_q) \right),$$

where we assuming, that $V(P) \to P(V)\gamma$ decay caused by electromagnetic interaction of structural quark and photon via (6).

[11] Haurysh, V. Yu., Andreev, V. V. ρ–,π–meson form-factor in the point form of Poincaré-invariant quantum mechanics / V. Yu. Haurysh, V. V. Andreev, V. V. // J. Phys. G: Nucl. Part. Phys–2025. – Vol. 52. – P. 035004.

Electroweak characteristic calculation

Note that in relation (10) auxiliary functions are introduced

$$f_1(\mathrm{k}, m_q, m_{\bar{Q}}) = \frac{\omega_{m_q}(\mathrm{k}) + \omega_{m_{\bar{Q}}}(\mathrm{k})}{3\,\omega_{m_q}(\mathrm{k})}\left(\frac{m_q + m_{\bar{Q}}}{\omega_{m_q}(\mathrm{k}) + \omega_{m_{\bar{Q}}}(\mathrm{k})} + \frac{m_q}{\omega_{m_q}(\mathrm{k})} + 1\right), \tag{25}$$

$$f_2(\mathrm{k}, m_q, m_{\bar{Q}}) = -\frac{2}{3}(\omega_{m_q}(\mathrm{k}) + \omega_{m_{\bar{Q}}}(\mathrm{k}))\frac{m_q^2 + \omega_{m_q}(\mathrm{k})(m_q + \omega_{m_q}(\mathrm{k}))}{\omega_{m_q}^2(\mathrm{k})}.$$

Using first set of model parameters (19) for $D^{*0}(2007) \to D^0\gamma$ decay constant one can get

$$g_{D^{*0}D^0\gamma} = (1.74 \pm 0.05)\ \mathrm{GeV}^{-1}; \tag{26}$$

Note that for (26) calculation value of c–quark magnetic moment was used

$$\kappa_c = 0.192 \pm 0.073, \quad \mu_c = \frac{e_c}{2\,m_c}(1 + \kappa_c) = (0.44 \pm 0.04)\ \mu_N. \tag{27}$$

Electroweak characteristic calculation

Table: Comparing radiative decay $D^{*0}(2007) \to D^0\gamma$ constant with other models and experimental data

	$g_{D^{*0}D^0\gamma}$, GeV^{-1}
Light-front calculation [12]	1.78
Light-cone sum rules [13]	-2.11 ± 0.35
Heavy quark effective theory [14]	1.91 ± 0.09
Lattice calculation [15]	2.00 ± 0.06
Experimental data [16]	–
This work	1.74 ± 0.05

Note, that in [17] using the isospin symmetry obtained value $g_{D^{*0}D^0\gamma} = (1.77 \pm 0.16)$ GeV^{-1}.

[12] Choi, H. M. Decay constants and radiative decays of heavy mesons in light-front quark model/ H. M. Choi // Phys. Rev. D–2007. – Vol. 75. – P. 073016.

[13] Pullin, B. Radiative decays of heavy-light mesons and the $f^{(T)}_{H,H^*,H_1}$ decay constants/ B. Pullin, R. Zwicky // JHEP–2021. – Vol. 09. – P. 023.

[14] Cheung, C. Strong and radiative decays of heavy mesons in a covariant model/ C. Cheung, C. Hwang // JHEP–2014. – Vol. 04. – P. 177.

[15] Becirevic, D. $D* \to D\pi$ and $D* \to D\gamma$ decays: Axial coupling and Magnetic moment of D* meson/ D. Becirevic, B. Haas // Eur. Phys. J. C–2011. – Vol. 71. – P. 1734.

[16] PDG group, Navas, S. Review of particle physics/ S. Navas and PDG group // Phys. Rev. D–2024. – Vol. 110(3) – P. 030001.

[17] Tran, Ch.-Th. Radiative decays $D_s^* \to D_s\gamma$ in covariant confined quark model/ Ch.-Th. Tran et all. // Chin. Phys. C–2024. – Vol. 48(2). – P. 023103.

Electroweak characteristic calculation

Similarly using parameters (19) for $D_s^{*\pm} \to D_s^{\pm}\gamma$ radiative decay constant one can get

$$g_{D_s^{*\pm}D_s^{\pm}\gamma} = -(0.15 \pm 0.03)\ \text{GeV}^{-1}. \tag{28}$$

Below we provide comparative analysis:

Table: Comparing radiative decay $D_s^{*\pm} \to D_s^{\pm}\gamma$ constant with other models and experimental data

	$g_{D_s^{*\pm}D_s^{\pm}\gamma}$, GeV^{-1}
Light-front calculation [18]	$-(0.16 \pm 0.07)$
Light-cone sum rules [19]	0.60 ± 0.19
Potential model of independent quarks [20]	-0.17
Experimental data [21]	–
This work	$-(0.15 \pm 0.03)$

[18] Choi, H. M. Decay constants and radiative decays of heavy mesons in light-front quark model/ H. M. Choi // Phys. Rev. D–2007. – Vol. 75. – P. 073016.

[19] Pullin, B. Radiative decays of heavy-light mesons and the $f^{(T)}_{H,H^*,H_1}$ decay constants/ B. Pullin, R. Zwicky // JHEP–2021. – Vol. 09. – P. 023.

[20] Barik, N. Radiative decay of light and heavy mesons/ N. Barik, P. C. Dash // Phys.Rev.D–1994. – Vol. 49. – P.299-308.

[21] PDG group, Navas, S. Review of particle physics/ S. Navas and PDG group // Phys. Rev. D–2024. – Vol. 110(3) – P. 030001.

What can we predict?

Using the relation for $V \to P\gamma$ decay wight [22]

$$\Gamma(V \to P\gamma) = \alpha \frac{g^2_{VP\gamma}}{3} \left(\frac{M_V^2 - M_P^2}{2\, M_V} \right)^3 \tag{29}$$

and experimental values of D^{*0}– and D^0–mesons masses with model estimation $g_{D^{*0}D^0\gamma} = (1.74 \pm 0.05)\ \text{GeV}^{-1}$ one can obtain

$$\Gamma\left(D^{*0} \to D^0\gamma\right) = (19.02 \pm 1.18)\ \text{keV}. \tag{30}$$

Branching fraction value[23] $\text{Br}(D^{*0} \to D^0\gamma) = (35.3 \pm 0.9)\,\%$ leads to full decay wight

$$\Gamma_{D^{*0}} = (53.89 \pm 3.62)\ \text{keV}, \tag{31}$$

which correlates with current experimental estimates $\Gamma_{D^{*0}} < 2.1\,\text{MeV}$ (CL=90 %).

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[22] Jaus, W. Relativistic constituent quark model of electroweak properties of light mesons / W. Jaus // Phys. Rev.-1991.-Vol. D44.-P. 2851-2859.

[23] Navas, S. et all (PDG group) Review of particle physics/ S. Navas and PDG group // Phys. Rev.–2024. – Vol. D110. – P. 030001.

What can we predict?

Same procedure for $D_s^{*\pm} \to D_s^{\pm}\gamma$ decay wight leads to

$$\Gamma\left(D_s^{*\pm} \to D_s^{\pm}\gamma\right) = (0.13 \pm 0.06)\ \text{keV} \tag{32}$$

or using [24] $\text{Br}(D_s^{*\pm} \to D_s^{\pm}\gamma) = (93.6 \pm 0.4)\,\%$

$$\Gamma_{D^{*0}} = (0.13 \pm 0.06)\ \text{keV}, \tag{33}$$

which also correlates with current experimental estimates $\Gamma_{D_s^{*\pm}} < 1.9\,\text{MeV}$ (CL=90 %).

For D^{*0}–, $D_s^{*\pm}$– resonances the dominant decay channel is pionic decay via $V \to P\pi$ and $V \to V'\pi$; in proposed approach pionic decay constant can be calculated using soft pion theorem [25, 26] .

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[24] Navas, S. et all (PDG group) Review of particle physics/ S. Navas and PDG group // Phys. Rev.–2024. – Vol. D110. – P. 030001.

[25] Das, T., Mathur, V. S. $A_1 \to \rho\pi$, $\rho \to 2\pi$ decays/ T. Das, V. S. Mathur, S. Okubo // Phys.Rev.Lett.–1967. – Vol. 19. – P. 1067-1070.

[26] Haurysh, V. Yu., Andreev, V. V. ρ-, π-meson form-factor in the point form of Poincaré-invariant quantum mechanics/ V. Yu. Haurysh, V. V. Andreev // Journal of Physics G: Nuclear and Particle Physics–2025. – Vol. 52(3). – P. 035004.

Conclusion and remarks

The work is devoted to calculations of the masses and electroweak decay constants of heavy pseudoscalar and vector D^{*0}–, D^{0}–, $D_s^{*\pm}$–, $D_s^{\pm}$– mesons in a model based on the composite quark model and the point form of PiQM. During the work authors demonstrate a procedure for calculating the eigenvalues of a 3×3 matrix using a system of analytical calculations [27], followed by the calculation of the masses of heavy D– resonances. A comparative analysis showed that the proposed calculation method yields satisfactory values for the heavy resonance mesons masses.

As a generalization, the authors demonstrated the calculation method of D^{*0}– and $D_s^{*\pm}$– vector mesons decay widths and compared obtained values with current experimental estimates. A comparative analysis showed that the developed model can also be used for electroweak decays characteristic of heavy mesons calculation.

[27] Wolfram Mathematica 14.3

THANK YOU FOR YOUR ATTENTION!

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