# Светлой памяти Михаила Константиновича Поливанова

посвящается

# Алгебраическая квантовая теория

$$\hat{H} = \hat{\vec{\alpha}}\vec{p} + \hat{\beta}(m_1 + m_2\hat{\gamma}_5)$$

$$\hat{\beta} = \hat{\gamma}_0$$

$$\hat{\vec{\alpha}} = \hat{\beta}\hat{\vec{\gamma}}$$

$$m^2 = m_1^2 - m_2^2$$

Кадышевский ${p_0}^2 - \vec{p}^2 + {p_5}^2 = M^2,\ m \leq M$

Бендер $PT$

Родионов $\Box - m^2 = \left(i\gamma^\mu \partial_\mu - (m_1 + m_2\,\gamma_5)\right) \cdot$

$\cdot \left(i\gamma^\nu \partial_\nu + (m_1 - m_2\,\gamma_5)\right)$

$$\widehat{H} = \hat{\vec{\alpha}}\vec{p} + \hat{\beta}(m_1 + m_2\hat{\gamma}_5)$$

$$\hat{\beta} = \hat{\gamma}_0 \quad \hat{\vec{\alpha}} = \hat{\beta}\hat{\vec{\gamma}}$$

$$m^2 = m_1^2 - m_2^2$$

$$\widehat{H} = \hat{\vec{\alpha}}\vec{p} + \hat{\beta} m e^{-\gamma_5 \alpha}$$

$$ch\,\alpha = \frac{m_1}{m} \quad sh\,\alpha = \frac{m_1}{m}$$

$$\widehat{H}_0 = \eta \widehat{H} \eta^{-1} \qquad \eta = e^{\alpha\gamma_5/_2}$$

$$\eta_0 \widehat{H} \eta_0^{\ -1} = \widehat{H}^{+} \quad \eta_0 = e^{\alpha\gamma_5}$$

- $\langle\psi|C \ldots|\psi\rangle$
- $C = \eta_0^{-1}\mathrm{P};\qquad C = e^{-\alpha\gamma_5}\gamma_0$
- $\overline{\psi}\hat{C}\psi = \psi^{+}\gamma_0\hat{C}\psi = \psi^{+}\gamma_0 e^{-\alpha\,\gamma_5}\gamma_0\,\psi =$
  - $ch\alpha = \frac{m_1}{m};\qquad sh\,\alpha = \frac{m_2}{m}$
- $= \psi^{+}\gamma_0\gamma_0\, e^{\alpha\gamma_5}\psi = \psi^{+}\, e^{\alpha\gamma_5}\psi =$
- $= \psi^{+}(ch\,\alpha + \gamma_5\, sh\,\alpha)\psi =$
- $= \psi^{+}\left(\frac{m_1}{m} + \gamma_5\,\frac{m_2}{m}\right)\psi$

$$D_M = i\gamma^{\mu}\partial_{\mu} - (m_1 + m_2\gamma_5\ )$$

$$\left(i\gamma^{\mu}\partial_{\mu} - (m_1 + m_2\gamma_5\ )\right)\Psi(x) = 0$$

$\psi(x) = \psi^{+}(\mathrm{x}) + \psi^{-}(\mathrm{x})$

$\left(\hat{k} + (m_1 + m_2\gamma_5\ )\right)\psi^{+}(\vec{k}) = 0$

$\left(\hat{k}\ - (m_1 + m_2\gamma_5\ )\right)\psi^{-}(\vec{k}) = 0$

$\psi^{+} = \begin{pmatrix}\psi_1\\ \psi_1\\ \psi_2\\ \psi_2\end{pmatrix}, \qquad \psi^{-} = \begin{pmatrix}\psi_2\\ \psi_2\\ \psi_1\\ \psi_1\end{pmatrix},$

- $\Psi_\alpha{}^{\pm}(\vec{k}) = \sum_{\nu=1,2} a_\nu{}^{\pm}(\vec{k})\, w_\alpha{}^{\nu,\pm}(\vec{k})$

- $\vec{k}$=0:

- $w_\alpha{}^{1,-}(\vec{0}) = \begin{pmatrix} 1 \\ 0 \\ \frac{m_2}{m+m_1} \\ 0 \end{pmatrix};\quad w_\alpha{}^{2,-}(\vec{0}) = \begin{pmatrix} 0 \\ 1 \\ 0 \\ \frac{m_2}{m+m_1} \end{pmatrix};$

- $w_\alpha{}^{1,+}(\vec{0}) = \begin{pmatrix} \frac{m_2}{m+m_1} \\ 0 \\ 1 \\ 0 \end{pmatrix};\quad w_\alpha{}^{2,+}(\vec{0}) = \begin{pmatrix} 0 \\ \frac{m_2}{m+m_1} \\ 0 \\ 1 \end{pmatrix}.$

- 1). $\left(w^{\nu,\pm}(\overrightarrow{k})\right)^{*} = w^{*\ \nu,\mp}(\vec{k})$
- 2). $w^{*\ \nu,\pm}(\vec{k})\ w^{\mu,\mp}(\vec{k}) =$
- $= \sum_{\alpha=1,\dots 4} w_{\alpha}{}^{*\ \nu,\pm}(\vec{k})\ w_{\alpha}{}^{\mu,\mp} = \delta^{\nu\mu}$
- 3). $w^{\mu,+}(\vec{k})\ \overline{w}^{\mu,-}(\vec{k}) = \frac{\hat{k} - (m_1 - m_2\gamma_5)}{2k^0}$
- $w^{\mu,-}(\vec{k})\ \overline{w}^{\mu,+}(\vec{k}) = \frac{\hat{k} + (m_1 - m_2\gamma_5)}{2k^0}$

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- $\left[\Psi_\alpha(x), \bar{\Psi}_\beta(y)\right]_+ = \frac{1}{i} S_{\alpha\beta}{}^{(M)}(x-y) =$

- $= \left(i\gamma^\mu \partial_\mu + (m_1 - m_2\gamma_5)\right)_{\alpha\beta} \frac{1}{i} D(x-y)$

- $\Psi(x)\bar{\Psi}(y) = :\Psi(x)\bar{\Psi}(y): + \underline{\Psi(x)\bar{\Psi}}(y)$

$$\underline{\Psi(x)\bar{\Psi}}(y) = \frac{1}{i} S_M{}^{-}(x-y)$$

$$\underline{\bar{\Psi}(x)\Psi}\,(y) = \frac{1}{i} S_M{}^{+}(y-x)$$

$$\mathrm{T}\Psi(\mathrm{x})\bar{\Psi}(\mathrm{y}) = :\Psi(\mathrm{x})\bar{\Psi}(\mathrm{y}): + \overline{\Psi(x)\bar{\Psi}(\mathrm{y})};$$

$$\overline{\Psi(x)\bar{\Psi}(\mathrm{y})} = \frac{1}{i}\left(i\gamma^{\mu}\partial_{\mu} + (m_1 - m_2\gamma_5)\right) D^{C}(x-y) =$$

$$= \left\langle \mathrm{T}\,\Psi(\mathrm{x})\bar{\Psi}(\mathrm{y})\right\rangle_0$$

$$m \overset{?}{\leftrightarrow} m_1,\ m_2$$

$$\mathrm{m},\ ? \leftrightarrow m_1,\ m_2$$

$(m^2 + m_2^2)/2 \geq \sqrt{m^2 m_2^2}$

$$m \leq \frac{{m_1}^2}{2m_2} \equiv m_{max}$$

$$m_{max} = M$$

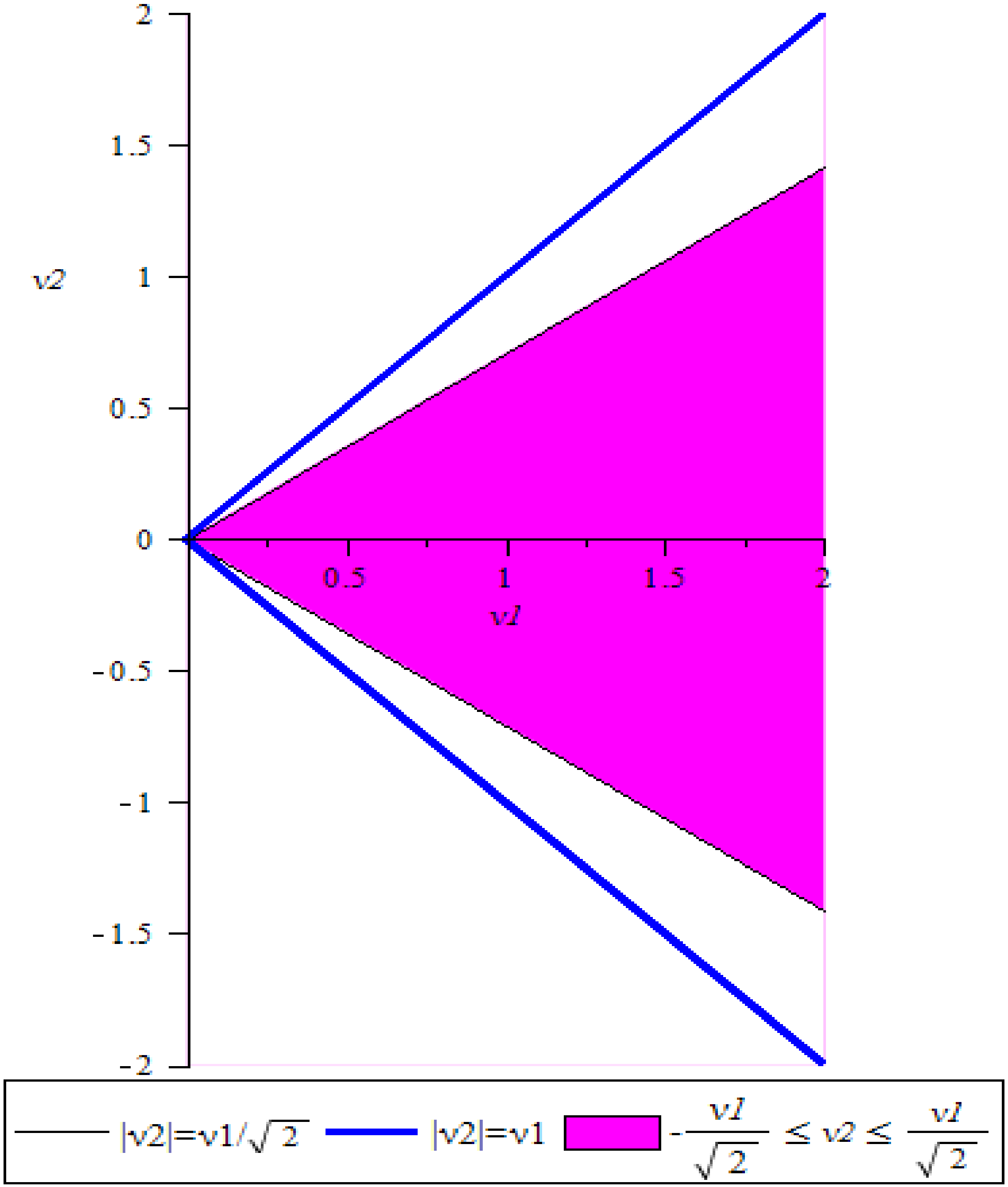
$$\mathrm{m},\ m_{max}=\mathrm{M} \leftrightarrow m_1,\ m_2$$

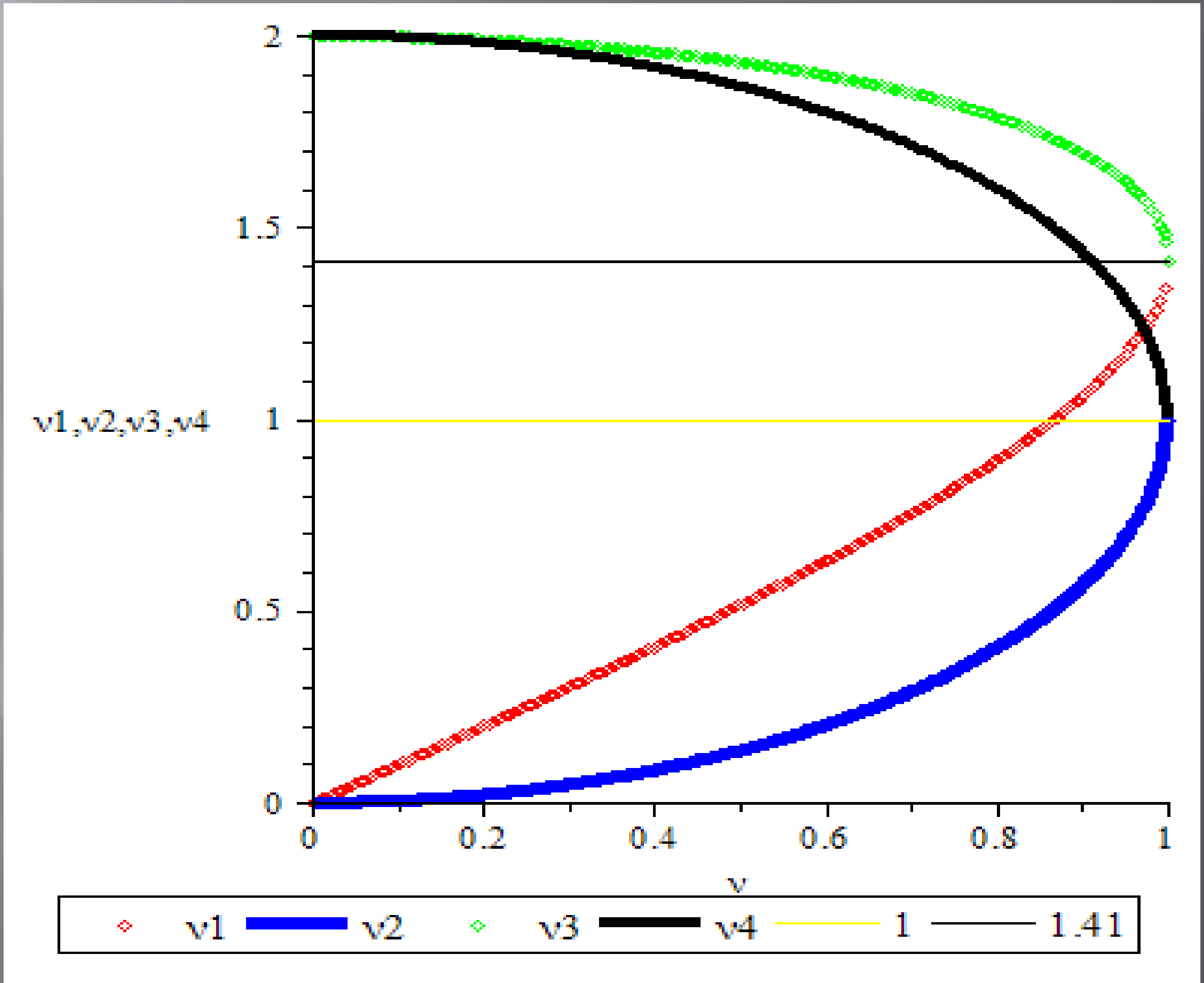
$$m^2 = {m_1}^2 - {m_2}^2$$

$$m_{max} = \frac{{m_1}^2}{2m_2}$$

$$m_1^{\mp} = \sqrt{2}\, m_{max} \sqrt{1 \mp \sqrt{1 - m^2/{m_{max}}^2}}$$

$$m_2^{\mp} = m_{max}\left(1 \mp \sqrt{1 - m^2/{m_{max}}^2}\right)$$


2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
v2
0.5
1
1.5
2
v1
|v2|=v1/√2
|v2|=v1
$-\frac{v1}{\sqrt{2}} \le v2 \le \frac{v1}{\sqrt{2}}$


2
1.5
1
0.5
0
v1,v2,v3,v4
0
0.2
0.4
0.6
0.8
1
v
v1
v2
v3
v4
1
1.41