Central exclusive production of the Pomeron tensor state in high-energy collisions of protons

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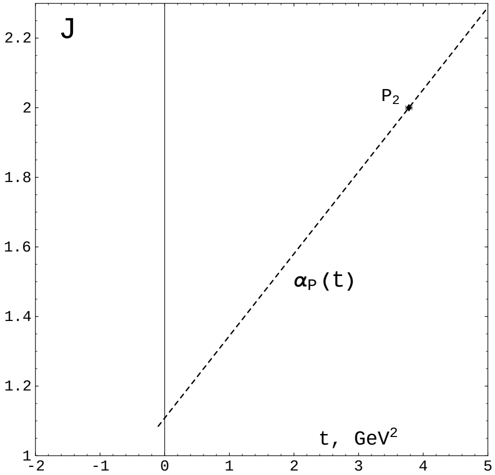
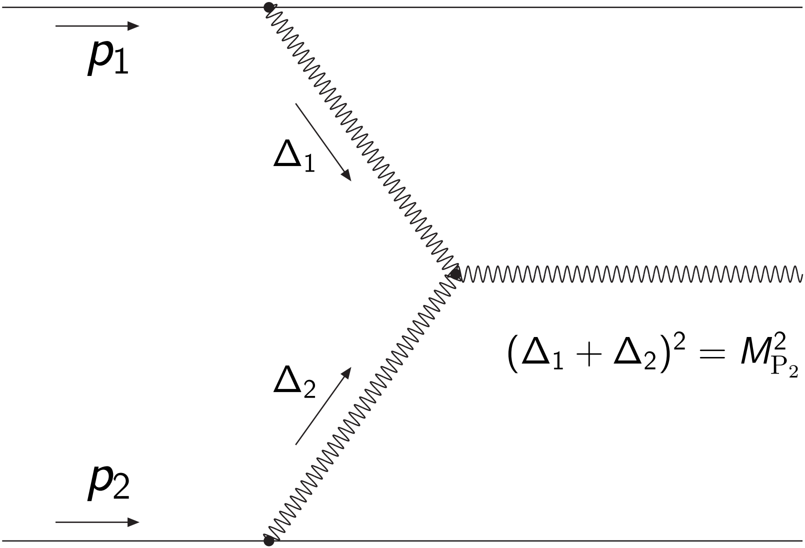
Expected behavior of the Pomeron Regge trajectory

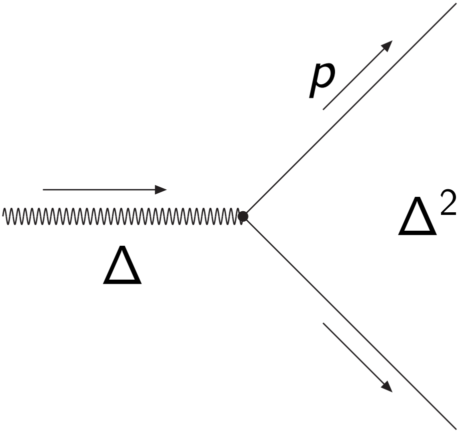


Central exclusive production of the Pomeron tensor state



$$(\Delta_1 + \Delta_2)^2 = M^2_{\mathrm{P}_2}$$

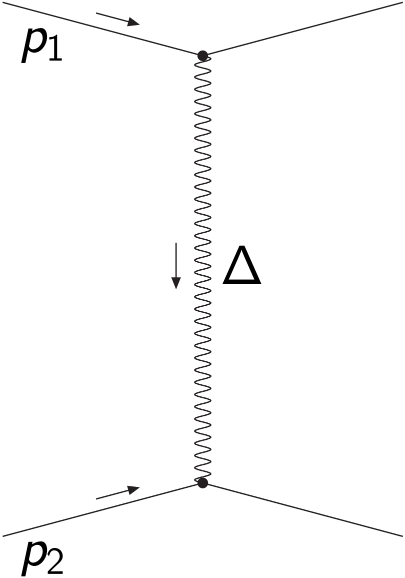
Pomeron decay to pair of light mesons



$$\Delta^2 = M^2_{\mathrm{P}_2}$$

Fitting the Pomeron Regge trajectory and the Pomeron coupling to proton

The Pomeron exchange contribution into Born amplitude



$$s = (p_1 + p_2)^2$$

$$t = \Delta^2$$

$$|t| \ll s$$

The simplest Regge-eikonal approximation for elastic *pp*-scattering

$$T(s,t) = 4\pi s \int_0^\infty db^2 J_0(b\sqrt{-t})\,\frac{e^{2i\delta(s,b)}-1}{2i}\,,$$

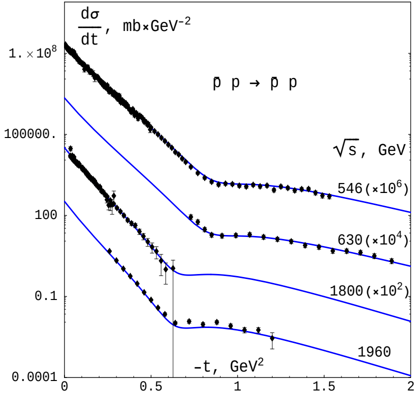
$$\delta(s,b) = \frac{1}{16\pi s}\int_0^\infty d(-t) J_0(b\sqrt{-t})\,\delta_{\mathrm{P}}(s,t)\,,$$

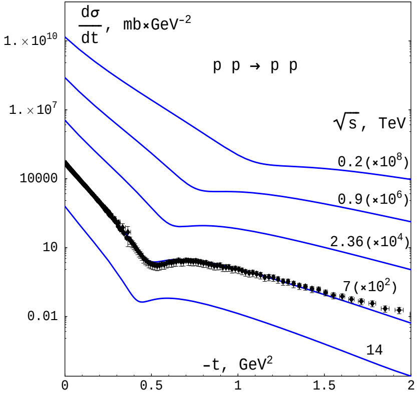
$$\delta_{\mathrm{P}}(s,t) = \xi(\alpha_{\mathrm{P}}(t))\, g_{\mathrm{P}}^2(t)\,\pi\alpha'_{\mathrm{P}}(t)\left(\frac{s}{2s_0}\right)^{\alpha_{\mathrm{P}}(t)}\,,$$

$$\xi(\alpha) \equiv i + \tan\frac{\pi(\alpha-1)}{2}\,.$$

High-energy elastic scattering of nucleons

A.A. Godizov, Eur. Phys. J. C **75** (2015) 224



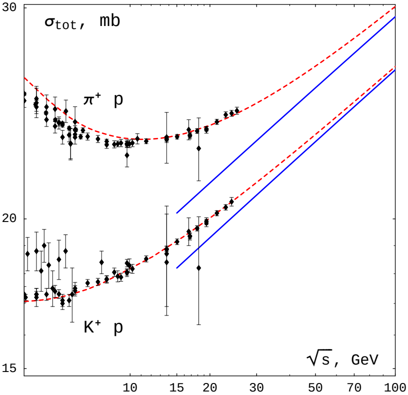


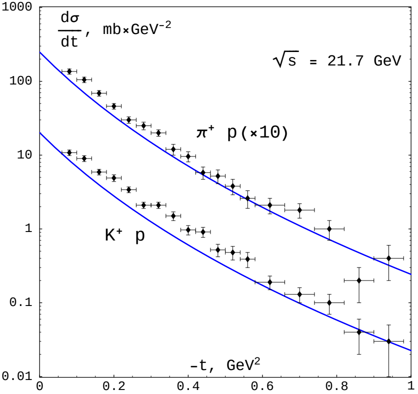
Extraction of the Pomeron couplings to light mesons

Elastic scattering of pseudoscalar mesons on protons

A.A. Godizov, Eur. Phys. J. C **76** (2016) 361:

$$g_{\pi\pi\mathrm{P}}(t) = g_{\pi\pi\mathrm{P}}(0) = 8.0\,\mathrm{GeV}\,, \qquad g_{KK\mathrm{P}}(t) = g_{KK\mathrm{P}}(0) = 7.1\,\mathrm{GeV}$$

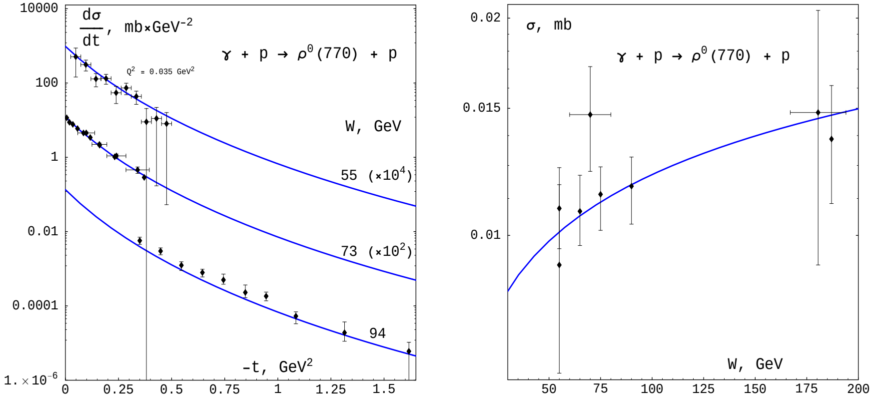




Exclusive photoproduction of vector mesons on protons

A.A. Godizov, Eur. Phys. J. C **76** (2016) 361:

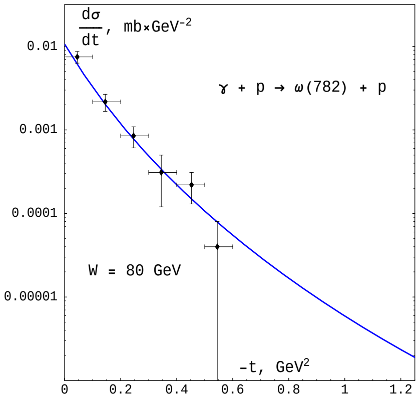
$$g_{\rho\rho\mathrm{P}}(t) = g_{\rho\rho\mathrm{P}}(0) = (7.07 \pm 0.27)\ \mathrm{GeV}$$

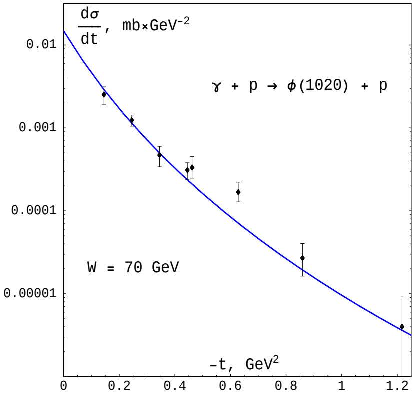


Exclusive photoproduction of vector mesons on protons

A.A. Godizov, Eur. Phys. J. C **76** (2016) 361:

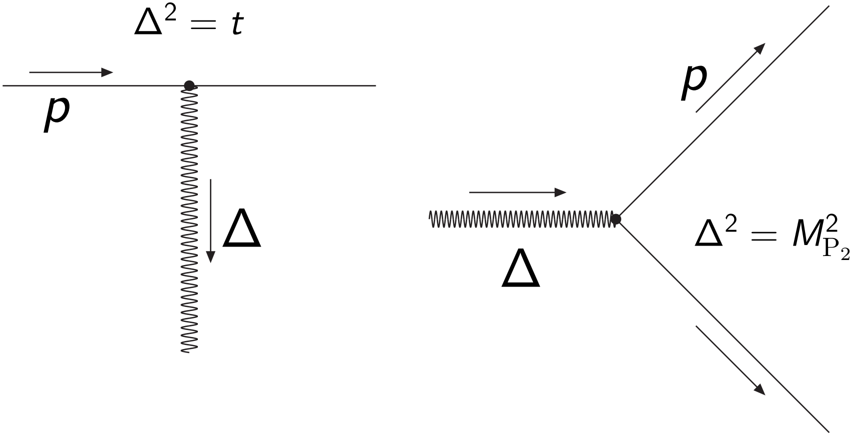
$$g_{\omega\omega\mathrm{P}}(t) = g_{\rho\rho\mathrm{P}}(0) = 7.07\,\mathrm{GeV}\,, \qquad g_{\phi\phi\mathrm{P}}(t) = g_{\phi\phi\mathrm{P}}(0) = 6.7\,\mathrm{GeV}$$





The Pomeron coupling to light mesons in the resonance region is comparable or even approximately equal to its coupling to the corresponding particles in the diffractive scattering regime.

The Pomeron coupling to light mesons



Predictions for $f_2(1950)$ resonance decays

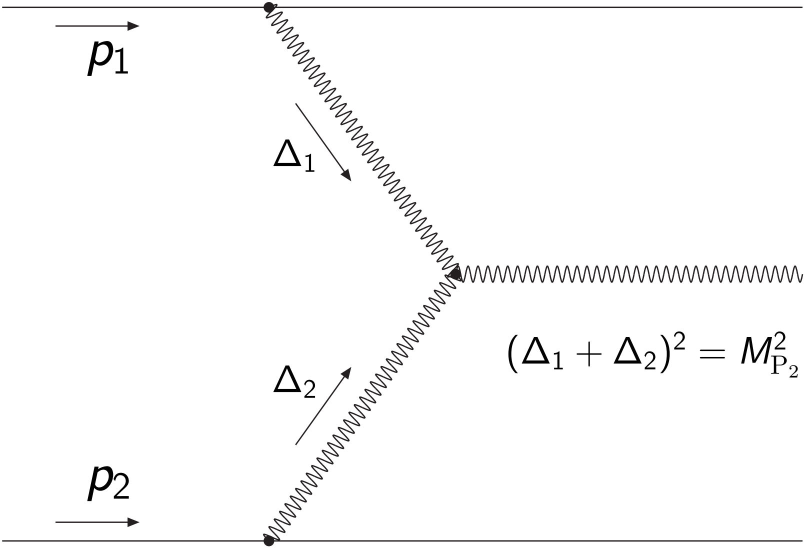
If $M_{\mathrm{P}_2} = M_{f_2(1950)}$, then

$$\Gamma_{\mathrm{P}_2 \to \pi^+\pi^-} \approx 75\,\mathrm{MeV}\,,$$

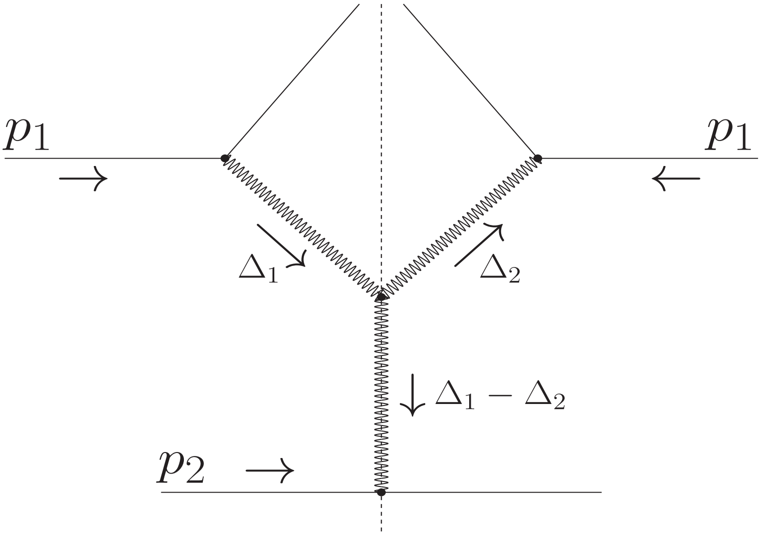
$$\Gamma_{\mathrm{P}_2 \to K^+K^-} \approx 30\,\mathrm{MeV}\,.$$

Cross-section of the P_2 exclusive central production

Central exclusive production of the Pomeron tensor state



Triple-Pomeron diagram for high-missing-mass SD

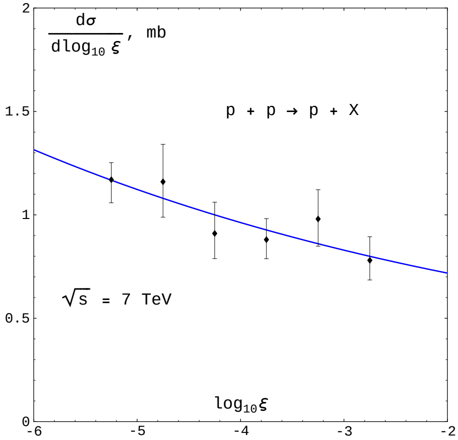


Due to the transversality and tracelessness of the P_2 helicity states the CEP of P_2 is dominated by the same vertex function as SD at high M_X.

Description of the CMS data on SD

A.A. Godizov, Nucl. Phys. A **955** (2016) 228:

$$g_{3P}(t_1, t_2, t_3) \approx g_{3P}(0,0,0) = 0.64\,\mathrm{GeV}$$



The SD t-slope at $\sqrt{s} = 1.8$ TeV

E-710 Collaboration (N.A. Amos *et al.*),
Phys. Lett. B **301** (1993) 313:

$$B^{E710} = (10.5 \pm 1.8)\, GeV^{-2} \quad (0.05\, GeV^2 \leq -t \leq 0.11\, GeV^2)$$

A.A. Godizov, Nucl. Phys. A **955** (2016) 228:

$$B^{model} \approx 11.7\, GeV^{-2}$$

Central exclusive production of $f_2(1950)$ in WA102

If $\quad g_{3\mathrm{P}}(t_1, t_2, M^2_{\mathrm{P}_2}) \approx g_{3\mathrm{P}}(0,0,0) = 0.64\,\mathrm{GeV}$

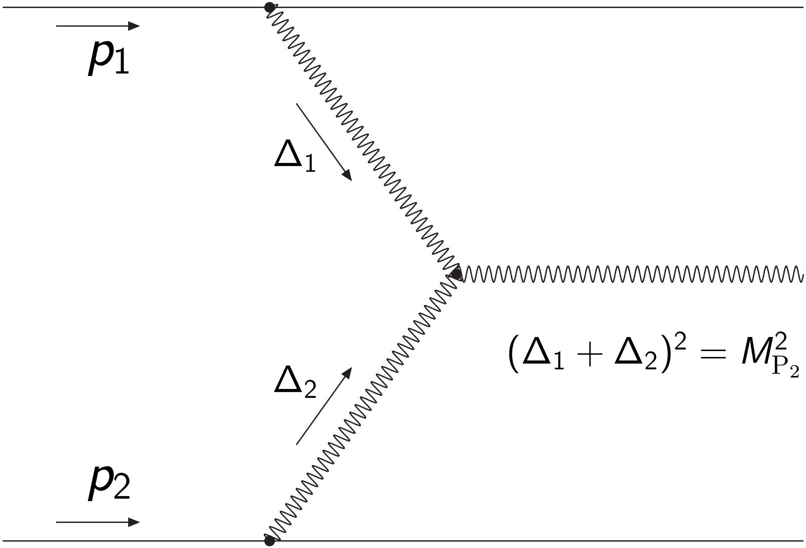
and $\quad M_{\mathrm{P}_2} = M_{f_2(1950)} \quad$ and $\quad \Gamma_{\mathrm{P}_2\to\mathrm{X}} = \Gamma_{f_2(1950)\to X}$,

then $\quad \sigma_{p+p\to p+\mathrm{P}_2+p}(29\,\mathrm{GeV}) \approx 0.7\,\mu b$.

A. Kirk, Phys. Lett. B **489** (2000) 29:

$\sigma_{p+p\to p+f_2(1950)+p}(29\,\mathrm{GeV}) = (2.788 \pm 0.175)\,\mu b$.

Central exclusive production of the Pomeron tensor state



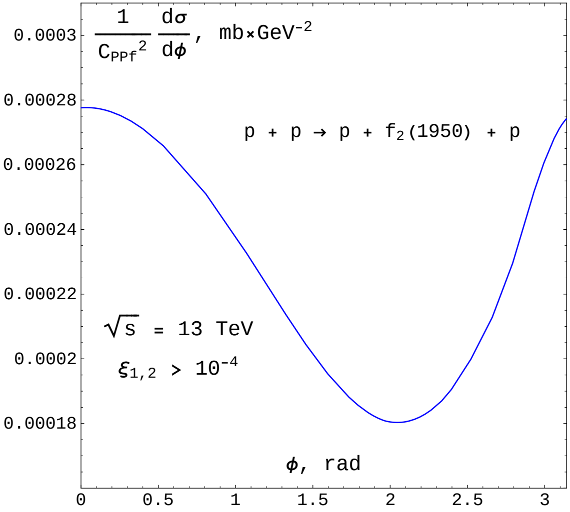
CEP of the Pomeron tensor state at $\sqrt{s} = 13$ TeV

If $\quad g_{3\mathrm{P}}(t_1, t_2, M^2_{\mathrm{P}_2}) \approx g_{3\mathrm{P}}(0,0,0) = 0.64\,\mathrm{GeV}$

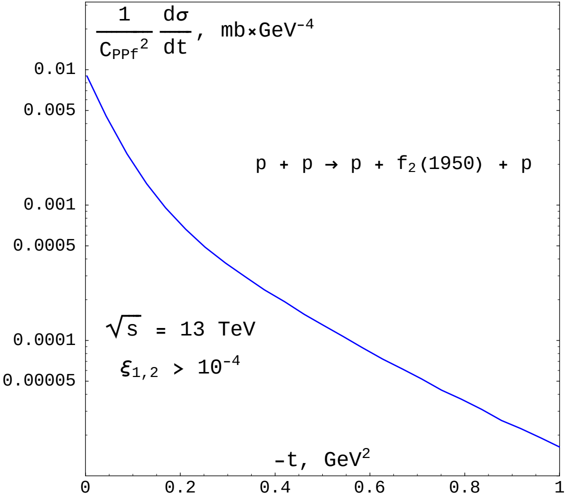
and $\quad M_{\mathrm{P}_2} = M_{f_2(1950)}$ $\quad$ and $\quad \Gamma_{\mathrm{P}_2 \to \mathrm{X}} = \Gamma_{f_2(1950)\to X}$,

then $\quad \sigma^{(\xi_{1,2} > 10^{-4})}_{p+p \to p+\mathrm{P}_2+p}(13\,\mathrm{TeV}) \approx 0.47\,\mu b$.

The ϕ-distribution at $\sqrt{s} = 13$ TeV



The t-distribution at $\sqrt{s} = 13$ TeV



Conclusion

Conclusion

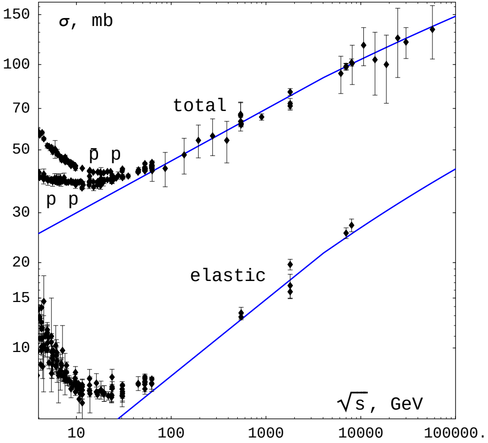
It is quite possible to identify the Pomeron tensor resonance, if to search it in exclusive 2-meson channels in high-energy collisions of protons.

Thank you for attention!

Backup slides

High-energy elastic scattering of nucleons

A.A. Godizov, Eur. Phys. J. C **75** (2015) 224



Spin-j resonance partial decay width

If a and b are scalar particles and R is a resonance of spin j, then

$$\Gamma^{(j)}_{\mathrm{R}\to a+b} = \frac{(j!)^2\,\lambda^{j+1/2}(M_{\mathrm{R}}^2, m_a^2, m_b^2)}{16\,\pi\,2^j\,(2j+1)!\,M_{\mathrm{R}}^{2j+3} s_0^j}\,\left|g_{ab\mathrm{R}}(M_{\mathrm{R}}^2)\right|^2$$

$\lambda(x,y,z) \equiv x^2+y^2+z^2-2\,x\,y-2\,y\,z-2\,x\,z, \qquad s_0 = 1\ \mathrm{GeV}^2$

Evolution of the ρ-Reggeon coupling to pions

$$\frac{|g_{\pi\pi\rho}(M^2_{\rho_3(1690)})|}{|g_{\pi\pi\rho}(M^2_{\rho(770)})|} = 1.1 \pm 0.05$$

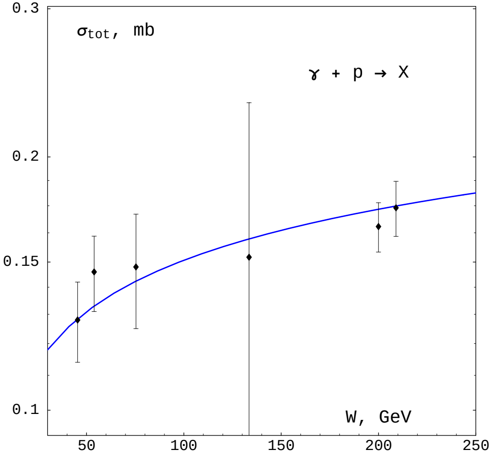
Evolution of the f-Reggeon coupling to pions

$$\frac{|g_{\pi\pi f}(M^2_{f_4(2050)})|}{|g_{\pi\pi f}(M^2_{f_2(1270)})|} = 0.56 \pm 0.06$$

Application to specific vacuum resonances

High-energy γp scattering

$$g_{\gamma\gamma\mathrm{P}}(0) = (39.7 \pm 0.7)\,\mathrm{MeV}$$



Predictions for $f_2(1950)$ resonance decays

$$\Gamma_{f_2(1950)\to\gamma\gamma} = (960 \pm 50)\,\mathrm{eV}$$

$$\Gamma_{f_2(1950)\to\pi^0\pi^0} = (37 \pm 1)\,\mathrm{MeV}$$

$$\Gamma_{f_2(1950)\to K^+K^-} = (29 \pm 1)\,\mathrm{MeV}$$

Predictions for $f_2(1950)$ resonance decays

A prediction:

$$\frac{\Gamma_{f_2(1950)\to\gamma\gamma}\Gamma_{f_2(1950)\to K^+K^-}}{\Gamma_{f_2(1950)\to X}} = (59\,\pm\,4)\ \mathrm{eV}$$

The BELLE Collaboration, Eur. Phys. J. C **32** (2004) 323:

$$\frac{\Gamma_{f_2(1950)\to\gamma\gamma}\Gamma_{f_2(1950)\to K^+K^-}}{\Gamma_{f_2(1950)\to X}} = (61 \pm 2 \pm 13)\ \mathrm{eV}$$

A prediction:

$$\frac{\Gamma_{f_2(1950)\to\gamma\gamma}\Gamma_{f_2(1950)\to\pi^0\pi^0}}{\Gamma_{f_2(1950)\to X}} = (75\,\pm\,5)\ \mathrm{eV}$$

The BELLE Collaboration, Phys. Rev. D **79** (2009) 052009:

$$\frac{\Gamma_{f_2(1950)\to\gamma\gamma}\Gamma_{f_2(1950)\to\pi^0\pi^0}}{\Gamma_{f_2(1950)\to X}} = 54^{+23}_{-14}\ \mathrm{eV}$$

Predictions for $f_2(2300)$ resonance decays

A prediction:

$$\frac{\Gamma_{f_2(2300)\to\gamma\gamma}\Gamma_{f_2(2300)\to K\bar{K}}}{\Gamma_{f_2(2300)\to X}} = (1300 \pm 370)\ \mathrm{eV}$$

The Belle Collaboration, Prog. Theor. Exp. Phys. **2013** 123C01:

$$\frac{\Gamma_{f_2(2300)\to\gamma\gamma}\Gamma_{f_2(2300)\to K\bar{K}}}{\Gamma_{f_2(2300)\to X}} = 3.2^{+0.5+1.3}_{-0.4-2.2}\ \mathrm{eV}$$

Predictions for $f_2(2220)$ resonance decays

A prediction:

$$\frac{\Gamma_{f_2(2220)\to\gamma\gamma}\Gamma_{f_2(2220)\to K\bar{K}}}{\Gamma_{f_2(2220)\to X}} = (7500 \pm 2700)\ \mathrm{eV}$$

The L3 Collaboration, Phys. Lett. B **501** (2001) 173:

$$\frac{\Gamma_{f_2(2220)\to\gamma\gamma}\Gamma_{f_2(2220)\to K\bar{K}}}{\Gamma_{f_2(2220)\to X}} < 1.4\ \mathrm{eV}$$

A prediction:

$$\frac{\Gamma_{f_2(2220)\to\gamma\gamma}\Gamma_{f_2(2220)\to \pi^+\pi^-}}{\Gamma_{f_2(2220)\to X}} = (7900 \pm 2900)\ \mathrm{eV}$$

The CLEO Collaboration, Phys. Rev. Lett. **81** (1998) 3328:

$$\frac{\Gamma_{f_2(2220)\to\gamma\gamma}\Gamma_{f_2(2220)\to \pi^+\pi^-}}{\Gamma_{f_2(2220)\to X}} < 2.5\ \mathrm{eV}$$

A.A. Godizov,

Eur. Phys. J. C **76** (2016) 361