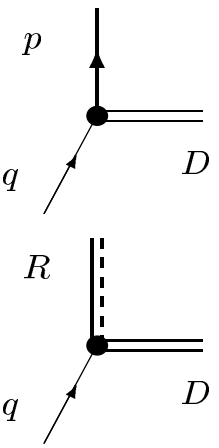
Spectator Model

$$|X\rangle \sim |D_f(qq)\ ,\ P_D^2 = M_D^2\rangle\ ;\ f = S, A \to D_S \equiv S, D_A \equiv A$$

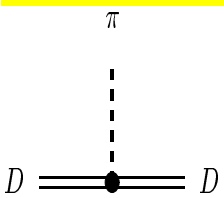
$$\Delta = \frac{\theta(P_D^+)}{(2\pi)^3}\,\delta\left((k-P_h)^2 - M_D^2\right)\ \langle 0|\psi(0)|\pi, p, D\rangle\langle D, p, \pi|\overline{\psi}(0)|0\rangle$$

Vertices :

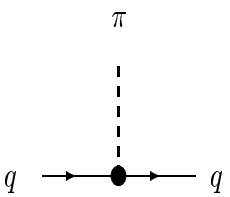
$$\begin{cases} \Upsilon^{\mathbf{qSp}} \equiv \Upsilon^{\mathbf{qSR}} = N_{qD}\ \mathbb{1}\ \dfrac{\tau_h - {m_q}^2}{|\tau_h - {\Lambda_N}^2|^2} \\ (\Upsilon^{\mathbf{qAp}})^\mu \equiv (\Upsilon^{\mathbf{qAR}})^\mu = \dfrac{N_{qD}}{\sqrt{3}}\,[\gamma_5\gamma^\mu]\,\dfrac{\tau_h - {m_q}^2}{|\tau_h - {\Lambda_N}^2|^2} \end{cases}$$



$$(\Upsilon^{\mathbf{A\pi A}})_{\mu\nu} = f_{D\pi D}\epsilon_{\mu\nu\rho\sigma}p_1^\rho p_2^\sigma$$



$$\Upsilon^{\mathbf{q\pi q}} = N_{q\pi}\gamma_5\frac{\tau_h - m_q^2}{|\tau_h - {\Lambda_\pi}^2|}$$

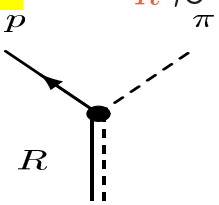


Propagators :

quark $\quad \dfrac{\mathrm{i}}{\not{k} - m_q}$

Roper $\quad \dfrac{\mathrm{i}\left(\not{P}_h + M_R\right)}{P_h^2 - {M_R}^2 + \mathrm{i}M_R\Gamma_R}$

$$\Upsilon^{\mathbf{p\pi R}} = N_R\gamma_5$$



Diquark $\ S \to \dfrac{\mathrm{i}}{P_D^2 - {M_S}^2}\ ;\ A \to \dfrac{\mathrm{i}}{P_D^2 - {M_A}^2}\left(-g^{\mu\nu} + \dfrac{P_D^\mu P_D^\nu}{P_D^2}\right)$