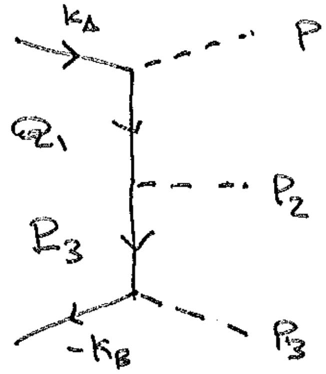

cf OCT 4 CALC CHECKING ARVIND

<u>TO DO</u>: CHECK $m_\varphi \to 0$ LIMIT w/ 0908.2258

$$Q_1 \equiv k_A - P_1$$
$$P_3 = P_3 - k_B$$

$$\text{vertex} = ig$$

for this diagram

$$i\mathcal{M}_{13} = ig^3\, \bar{v}_B\, \frac{-\not{P}_3 + m}{P_3^2 - m^2}\, \frac{\not{Q}_1 + m}{Q_1^2 - m^2}\, \gamma^5 u_A$$

<u>NON-RELATIVISTIC LIMIT</u>:

$$\begin{cases} k_{A,B} \longrightarrow (m, \vec{0}) \\ u \longrightarrow \sqrt{m}\begin{pmatrix}\xi\\ \xi\end{pmatrix} \\ \bar{v} \longrightarrow \sqrt{m}(-\eta^T, \eta^T) \\ \bar{v}\gamma^0 = -\bar{v} \\ \gamma^0 u = u \end{cases}$$

$$\bar{v}_B(-\not{P}_3 + m)(\not{Q}_1 + m)\gamma^5 u_A \xrightarrow{NR}$$

$$\bar{v}_B \Big\{ (P_3^0 + m)(-Q_1^0 + m)$$
$$(P_3^0 + m)(Q_1^i \gamma_j) \longleftarrow \text{zero from } \bar{v}\gamma^i\gamma^5 u$$
$$(-P_3^i \gamma_i)(-Q_1^0 + m)$$
$$(-P_3^i \gamma_i)(Q_1^i \gamma_j) \Big\} \gamma^5 u_A$$

$$\bar{v}\gamma^5 u = -2m\eta\cdot\xi$$
$$\bar{v}\gamma^i\gamma^5 u = 0$$
$$\bar{v}\gamma^i\gamma^j\gamma^5 u = 2m\eta \cdot \underbrace{\sigma^i\sigma^j}_{\delta^{ij} + i\epsilon^{ijk}\sigma^k}\xi$$

$$\bar{v}_B(-\not{P}_3+m)(\not{Q}_1+m)\gamma^5 u_A \longrightarrow$$

$$-2m(P_3^0+m)(-Q_1^0+m)\,\eta\cdot\xi$$
$$-2m(\vec{P}_3\cdot\vec{Q}_1)\,\eta\cdot\xi \quad -2m\,\eta\cdot(i P_3^i Q_1^j \sigma^k \epsilon^{ijk})\xi$$

note: this is antisymmetric in P_3 & P_1 and cancels when summing over diagrams.

$$\equiv -2m\, C_{31}\, \eta\cdot\xi$$

DENOMINATOR: $(P_3^2-m^2)(Q_1^2-m^2) = (M_\varphi^2-2mE_3)(M_\varphi^2-2mE_1)$
$\equiv D_{31}$

$$i\mathcal{M}_{31} = -2m\,\frac{C_{31}}{D_{31}}\,(\eta\cdot\xi)$$

this makes summing over spins really easy: $\mathcal{M}_{\pm\pm}\neq 0$, $\mathcal{M}_{\mp\pm}=0$

$$i\mathcal{M} = \sum_{AB} i\mathcal{M}_{AB}\Big|_{A\neq B} = -2m(\eta\cdot\xi)\sum_{AB}\frac{C_{AB}}{D_{AB}}\Big|_{A\neq B}$$

$$R_{AB}\equiv\frac{C_{AB}}{D_{AB}} = \frac{(P_A^0+m)(-Q_B^0+m)+\vec{P}_A\cdot\vec{Q}_B}{(M_\varphi^2-2mE_A)(M_\varphi^2-2mE_B)}$$

$$i\mathcal{M} = \sum_{AB} -2m(\eta\cdot\xi)\,R_{AB}\Big|_{A\neq B}$$

$$\boxed{\frac{1}{4}\sum_{\text{SPINS}}|\mathcal{M}|^2 = \cancel{4}m^2\sum_{ABCD} R_{AB}\big|_{A\neq B}\left(R_{CD}\big|_{C\neq D}\right)^* \cdot \cancel{\tfrac{1}{4}}}$$

check: do I care about it PART? well it $\sim g_3^2 m$ so it's small.