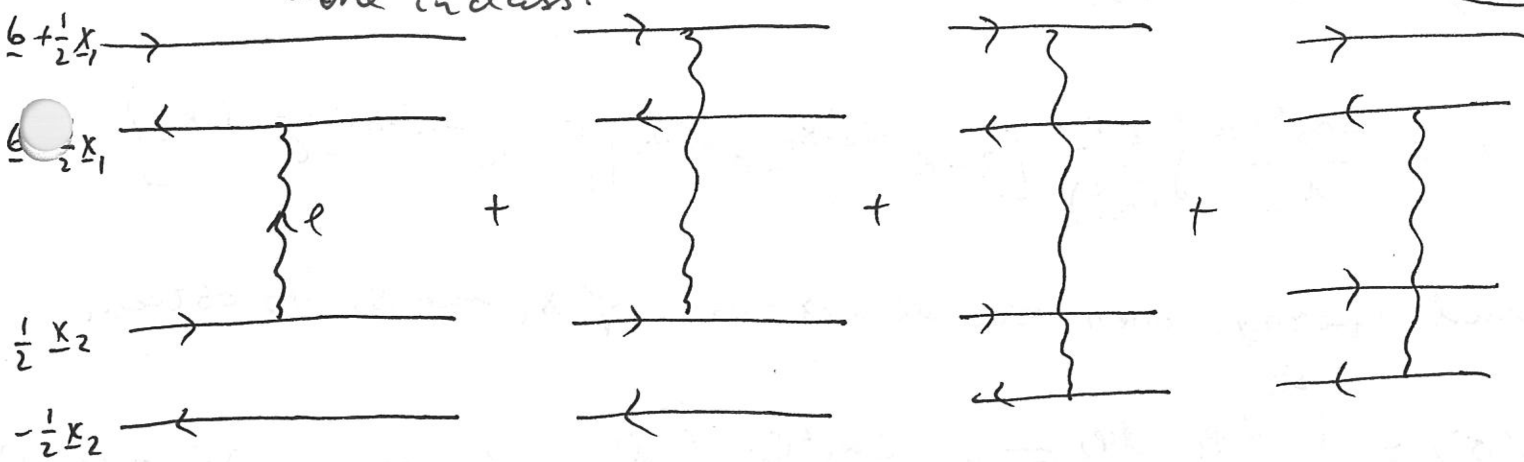
(a) Like done in class:



$$A = (-g^2) \int \frac{d^2 l_\perp}{(2\pi)^2} \frac{1}{l_\perp^2} \Big[- e^{i\underline{l}\cdot(\underline{b}-\frac{1}{2}\underline{x}_1-\frac{1}{2}\underline{x}_2)} + e^{i\underline{l}\cdot(\underline{b}+\frac{1}{2}\underline{x}_1-\frac{1}{2}\underline{x}_2)}$$

$$- e^{i\underline{l}\cdot(\underline{b}+\frac{1}{2}\underline{x}_1-(-\frac{1}{2}\underline{x}_2))} + e^{i\underline{l}\cdot(\underline{b}-\frac{1}{2}\underline{x}_1-(-\frac{1}{2}\underline{x}_2))}\Big] =$$

$$= g^2 \int \frac{d^2 l_\perp}{(2\pi)^2} \frac{1}{l_\perp^2} e^{i\underline{l}\cdot\underline{b}} \left[e^{i\underline{l}\cdot\frac{1}{2}\underline{x}_1} - e^{-i\underline{l}\cdot\frac{1}{2}\underline{x}_1}\right]\left[e^{i\underline{l}\cdot\frac{1}{2}\underline{x}_2} - e^{-i\underline{l}\cdot\frac{1}{2}\underline{x}_2}\right]$$

$$\Rightarrow \int |A|^2 d^2 b = g^4 \int d^2 b \int \frac{d^2 l}{(2\pi)^2} \frac{1}{l_\perp^2} e^{i\underline{l}\cdot\underline{b}} \left[e^{i\underline{l}\cdot\frac{1}{2}\underline{x}_1} - e^{-i\underline{l}\cdot\frac{1}{2}\underline{x}_1}\right]$$

$$\cdot \left[e^{i\underline{l}\cdot\frac{1}{2}\underline{x}_2} - e^{-i\underline{l}\cdot\frac{1}{2}\underline{x}_2}\right] \int \frac{d^2 l'}{(2\pi)^2} \frac{1}{\underline{l}_\perp'^2} e^{-i\underline{l}'\cdot\underline{b}} \left[e^{-i\underline{l}'\cdot\frac{1}{2}\underline{x}_1} - e^{i\underline{l}'\cdot\frac{1}{2}\underline{x}_1}\right]$$

$$\cdot \left[e^{-i\underline{l}'\cdot\frac{1}{2}\underline{x}_2} - e^{i\underline{l}'\cdot\frac{1}{2}\underline{x}_2}\right] = g^4 \int \frac{d^2 l_\perp}{(2\pi)^2} \frac{1}{(l_\perp^2)^2} \left| e^{i\underline{l}\cdot\frac{1}{2}\underline{x}_1} - e^{-i\underline{l}\cdot\frac{1}{2}\underline{x}_1}\right|^2$$

$$\cdot \left| e^{i\underline{l}\cdot\frac{1}{2}\underline{x}_2} - e^{-i\underline{l}\cdot\frac{1}{2}\underline{x}_2}\right|^2 = g^4 \int \frac{d^2 l_\perp}{(2\pi)^2} \frac{1}{(l_\perp^2)^2} \underbrace{\left[2 - e^{i\underline{l}\cdot\underline{x}_1} - e^{-i\underline{l}\cdot\underline{x}_1}\right]}_{\text{impact factor}} \cdot$$

$$\cdot \underbrace{\left[2 - e^{i\underline{l}\cdot\underline{x}_2} - e^{-i\underline{l}\cdot\underline{x}_2}\right]}_{\text{impact factor}} \Rightarrow \text{leads to Eq. (3.24).}$$

(6) Start from

$$\sigma = \frac{2\alpha_s^2 C_F}{N_c} \int \frac{d^2 l_\perp}{(l_\perp^2)^2} \left[2 - e^{-i\underline{l}\cdot\underline{x}_1} - e^{i\underline{l}\cdot\underline{x}_1}\right]\left[2 - e^{-i\underline{l}\cdot\underline{x}_2} - e^{i\underline{l}\cdot\underline{x}_2}\right]$$

and average over the directions of $\underline{x}_1$ and $\underline{x}_2$ to obtain

$$\langle\sigma\rangle = \int_0^{2\pi} \frac{d\varphi_1}{2\pi} \frac{d\varphi_2}{2\pi}\, \sigma = \frac{2\alpha_s^2 C_F}{N_c} 2\pi \int_0^\infty \frac{dl}{l^3} \cdot 4\left(1 - J_0(l x_1)\right)\left(1 - J_0(l x_2)\right)$$

$$= \frac{16\pi\alpha_s^2 C_F}{N_c} \lim_{\varepsilon\to 0} \left\{ \int_0^\infty \frac{dl}{l^{3-\varepsilon}} \left(1 - J_0(x_1)\right) - \int_0^\infty \frac{dl}{l^{3-\varepsilon}} J_0(l x_2) + \int_0^\infty \frac{dl}{l^{3-\varepsilon}} J_0(l x_1) J_0(l x_2) \right\}$$

$$= \frac{16\pi\alpha_s^2 C_F}{N_c} \lim_{\varepsilon\to 0} \left\{ - 2^{\varepsilon-3} x_1^{2-\varepsilon} \frac{\Gamma(-1+\frac{\varepsilon}{2})}{\Gamma(2-\frac{\varepsilon}{2})} - 2^{\varepsilon-3} x_2^{2-\varepsilon} \frac{\Gamma(-1+\frac{\varepsilon}{2})}{\Gamma(2-\frac{\varepsilon}{2})} \right.$$

$$\left. + \; 2^{\varepsilon-3} x_>^{2-\varepsilon} \frac{\Gamma(-1+\frac{\varepsilon}{2})}{\Gamma(2-\frac{\varepsilon}{2})} \, {}_2F_1\!\left(-1+\frac{\varepsilon}{2}, -1+\frac{\varepsilon}{2}; 1; \frac{x_<^2}{x_>^2}\right) \right\} =$$

$$= \frac{4\pi\alpha_s^2 C_F}{N_c} x_<^2 \left[\ln\left(\frac{x_>}{x_<}\right) + 1\right],$$ which is exactly

Eq. (3.25) in KL, as desired!