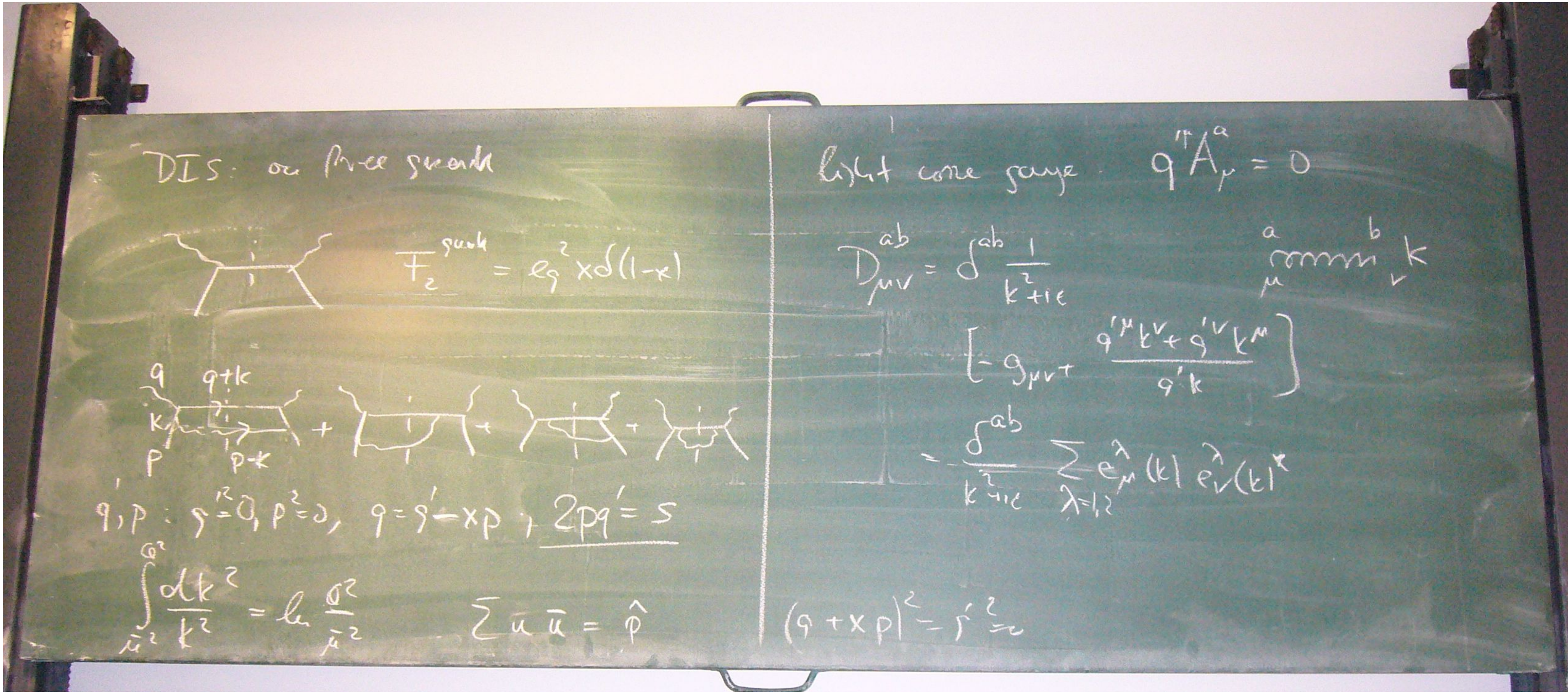
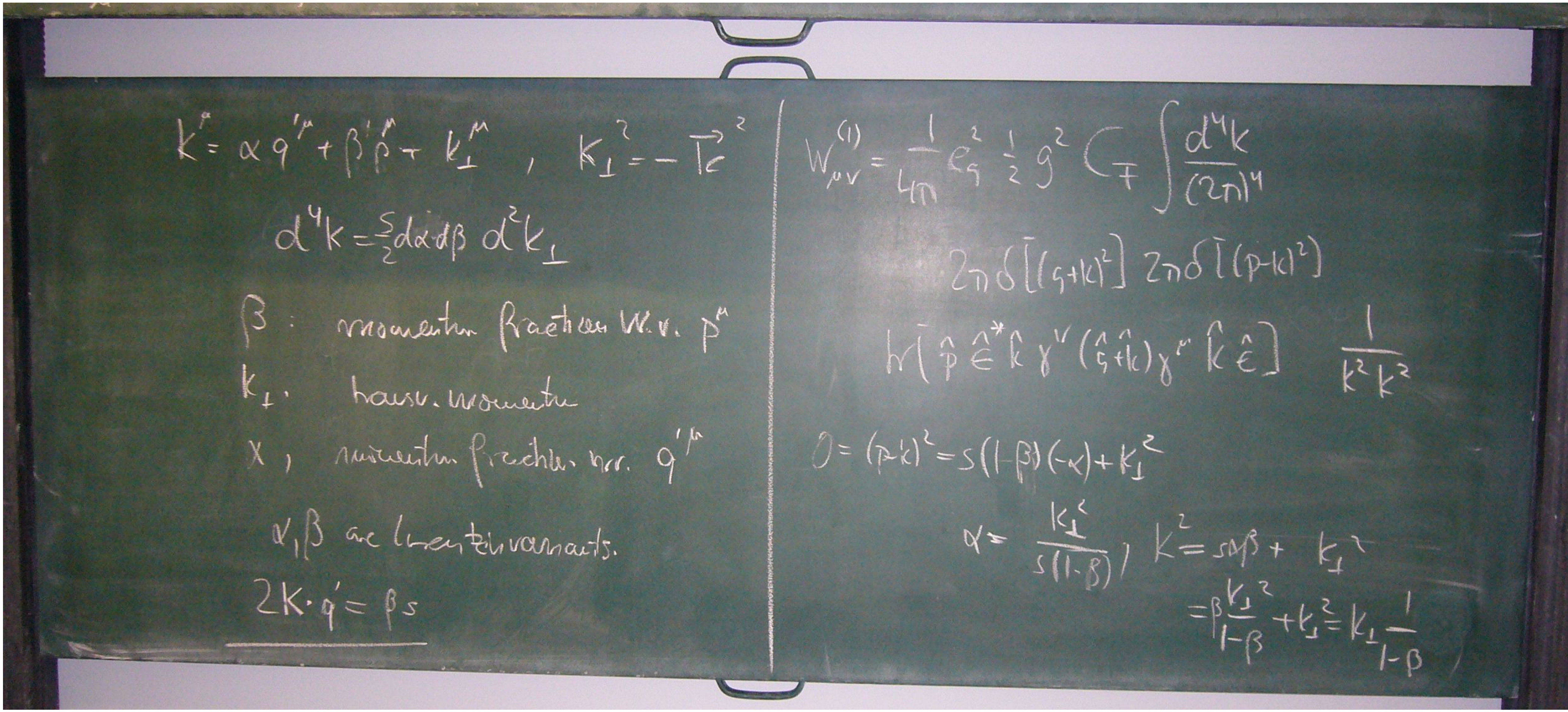
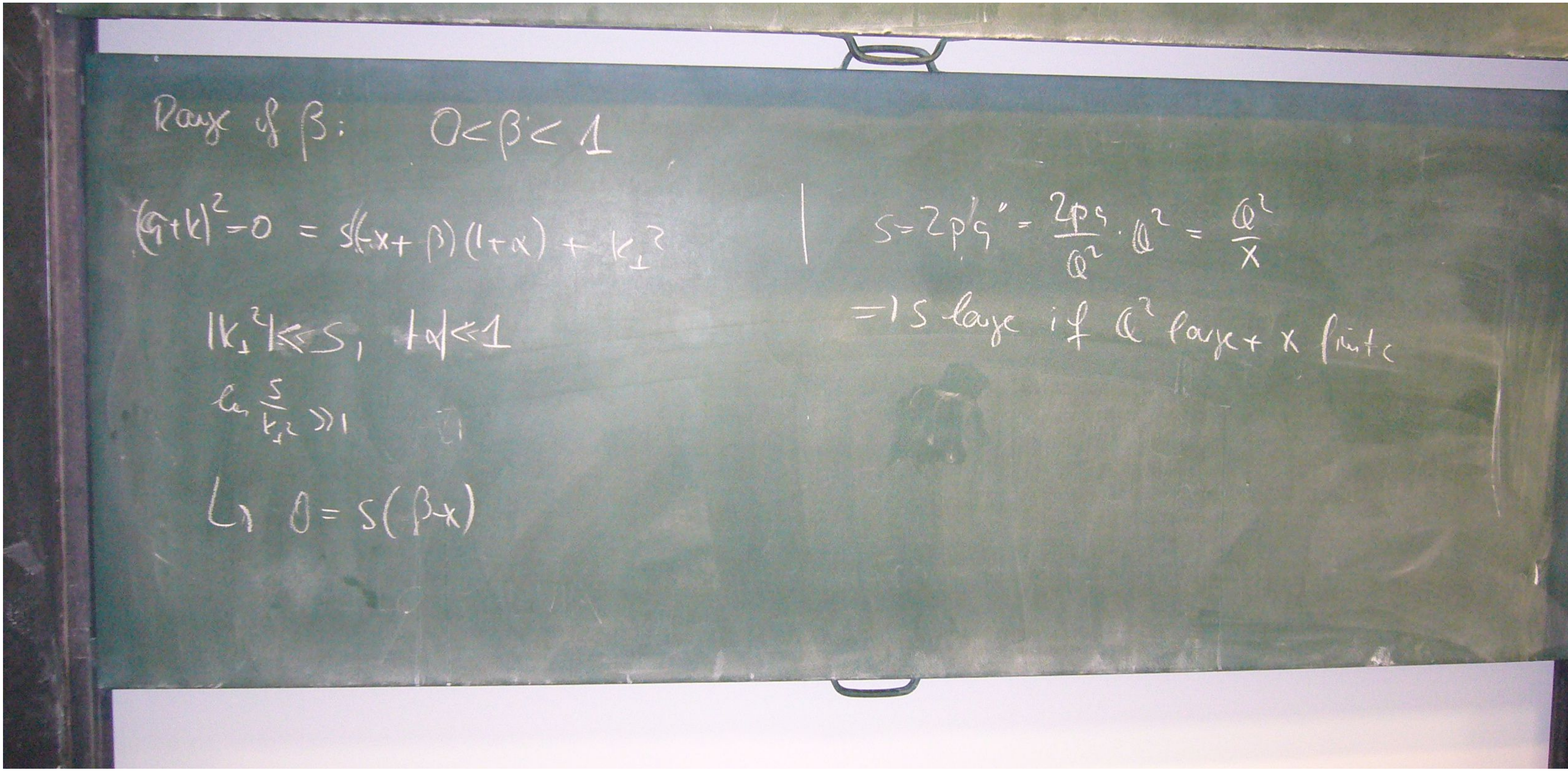
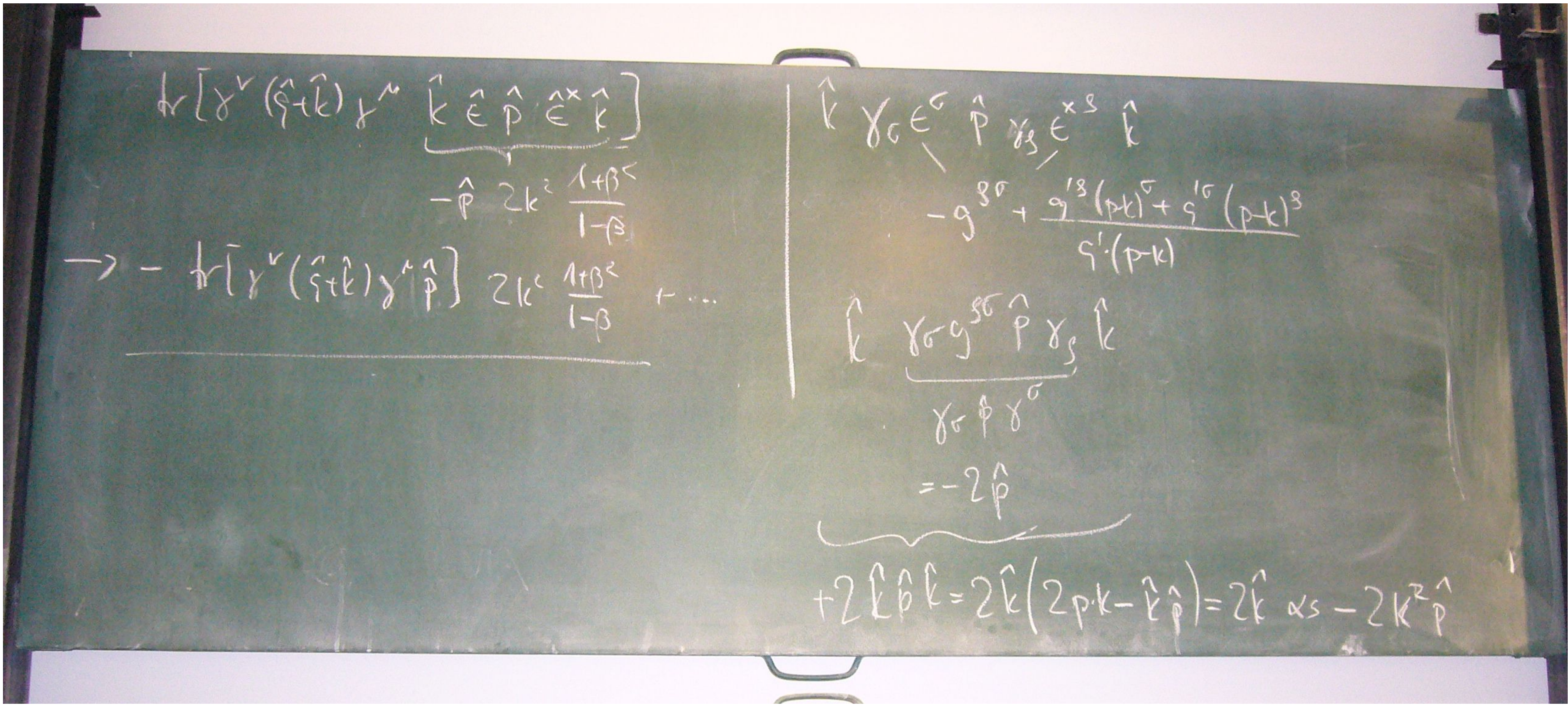

DIS: on free quark
F2^quark = eq^2 x δ(1-x)
q q+k
k
p p-k
q, p : q'^2 = 0, p^2 = 0, q = q' - xp , 2pq' = s
∫ dk^2/k^2 = ln Q^2/μ^2
Σ u ū = p̂
light cone gauge q'^μ A_μ^a = 0
D_μν^ab = δ^ab 1/(k^2+iε) [-g_μν + (q'^μ k^ν + q'^ν k^μ)/(q'k)]
= - δ^ab/(k^2+iε) Σ_λ=1,2 e_μ^λ(k) e_ν^λ(k)*
(q + xp)^2 = q'^2 = 0



$k^\mu = \alpha q'^\mu + \beta p^\mu + k_\perp^\mu \,, \quad k_\perp^2 = -\vec{k}^2$
$d^4k = \frac{s}{2} d\alpha\, d\beta\, d^2k_\perp$
β: momentum fraction w.r.t. p^μ
$k_\perp$: transv. momentum
α, momentum fraction w.r.t. q'^μ
α, β are Lorentz invariants.
$2k\cdot q' = \beta s$
$W^{(1)}_{\mu\nu} = \frac{1}{4\pi} e_q^2 \frac{1}{2} g^2 C_F \int \frac{d^4k}{(2\pi)^4}$
$2\pi\delta[(q+k)^2]\, 2\pi\delta[(p-k)^2]$
$\mathrm{tr}[\hat{p}\,\hat{\epsilon}^*\hat{k}\,\gamma^\nu(\hat{q}+\hat{k})\gamma^\mu\hat{k}\,\hat{\epsilon}] \quad \frac{1}{k^2 k^2}$
$0 = (p-k)^2 = s(1-\beta)(-\alpha) + k_\perp^2$
$\alpha = \frac{k_\perp^2}{s(1-\beta)}, \quad k^2 = s\alpha\beta + k_\perp^2$
$= \beta\frac{k_\perp^2}{1-\beta} + k_\perp^2 = k_\perp^2 \frac{1}{1-\beta}$


Range of β: $0<\beta<1$
$(q+k)^2=0 = s(-x+\beta)(1+\alpha) + k_\perp^2$
$s = 2p'q'' = \frac{2pq}{Q^2}\cdot Q^2 = \frac{Q^2}{x}$
$\Rightarrow s$ large if Q^2 large + x finite
$|k_\perp^2| \ll s$, $|\alpha| \ll 1$
$\ln \frac{s}{k_\perp^2} \gg 1$
$\hookrightarrow 0 = s(\beta - x)$


$tr[\gamma^\nu (\hat{q}+\hat{k}) \gamma^\mu \hat{k} \hat{\epsilon} \hat{p} \hat{\epsilon}^* \hat{k}]$
$-\hat{p}\ 2k^2 \frac{1+\beta^2}{1-\beta}$
$\to -tr[\gamma^\nu (\hat{q}+\hat{k}) \gamma^\mu \hat{p}]\ 2k^2 \frac{1+\beta^2}{1-\beta} + \dots$
$\hat{k}\ \gamma_\sigma \epsilon^\sigma\ \hat{p}\ \gamma_\rho \epsilon^{*\rho}\ \hat{k}$
$-g^{\rho\sigma} + \frac{q'^\rho (p-k)^\sigma + q'^\sigma (p-k)^\rho}{q'\cdot(p-k)}$
$\hat{k}\ \gamma_\sigma g^{\rho\sigma} \hat{p} \gamma_\rho\ \hat{k}$
$\gamma_\sigma \hat{p} \gamma^\sigma$
$= -2\hat{p}$
$+2\hat{k}\hat{p}\hat{k} = 2\hat{k}(2p\cdot k - \hat{k}\hat{p}) = 2\hat{k}\ \alpha s - 2k^2\hat{p}$

$$W_{\mu\nu}^{(1)} = \frac{1}{4\pi} e_q^2 \, \frac{1}{2} g^2 \, C_F \, \frac{s}{2} \int \frac{d\alpha \, d\beta \, d^2k_\perp}{(2\pi)^4} (2\pi)^2 \, \frac{\delta\left(-\alpha + \frac{k_\perp^2}{s(1-\beta)}\right)}{s(1-\beta)} \, \delta(s(\beta - x))$$

$$dx \left[\ldots \right]$$

$$\frac{d^2k_\perp}{1-\beta} = \pi \frac{d|k_\perp^2|}{1-\beta} = \pi \, d|k|^2$$

$$d^2k_\perp = dk_x \, dk_y = d\varphi \, |\vec{k}| \, d|\vec{k}|$$

$$= 2\pi \, \frac{1}{2} d|\vec{k}|^2$$

$$= 2\hat{k}\, k^2 - 2k^2\hat{p}$$

$$\approx 2\beta\hat{p}\, k^2 - 2k^2\hat{p}$$

$$= 2(\beta-1)\, k^2\hat{p}$$

$$\frac{\hat{k}\hat{q}'\hat{p}(\hat{p}-\hat{k})\hat{k} + \hat{k}(\hat{p}-\hat{k})\hat{p}\hat{q}'\hat{k}}{q'(p-k)} - \frac{s\beta k^2\hat{p}}{\frac{1}{2}s(1-\beta)}$$

$$q'(p-k) = \frac{1}{2}s(1-\beta)$$

$$\hat{k}\hat{q}'(-\hat{p}\hat{k})\hat{k}$$

$$= -\hat{k}\hat{q}'\hat{p}k^2$$

$$\approx -\beta\hat{p}\hat{q}'\hat{p}k^2$$

$$= -\frac{1}{2}s\beta\, k^2\hat{p}$$

$$= -2\frac{\beta}{1-\beta}k^2\hat{p}$$

$$= -2\hat{\beta}k^2 \underbrace{\left[1-\beta+\frac{2\beta}{1-\beta}\right]}_{\frac{(1-\beta)^2+2\beta}{1-\beta}=\frac{1+\beta^2}{1-\beta}}$$

$$= -2\hat{\beta}k^2 \, \frac{1+\beta^2}{1-\beta}$$