Session of Monday 6 October at 16.00-17.30 in aud A315.

1. (a) Prove the following identity for a fermion propagator:

$$\frac{\not{p}+m}{p^2-m^2+i\varepsilon}=\frac{1}{2E_p}\sum_s\left[\frac{u(\boldsymbol{p},s)\bar{u}(\boldsymbol{p},s)}{p^0-E_p+i\varepsilon}+\frac{v(-\boldsymbol{p},s)\bar{v}(-\boldsymbol{p},s)}{p^0+E_p-i\varepsilon}\right]$$

where $E_p=+\sqrt{\boldsymbol{p}^2+m^2}$. Note that the spinors are independent of p^0.
Do a Fourier transform of the propagator from p^0 to time t, and give an interpretation of the two terms on the *rhs.*

(b) Find the corresponding identity in terms of the LF spinors defined in eqs. (14) - (15) of the "LF Spinors and Polarization Vectors" file on the home page, where the '$-$' momentum in the spinors is defined to be $p^-_{LF}\equiv(\boldsymbol{p}_\perp^2+m^2)/p^+$.
Do a Fourier transform from p^- to x^+ and give your interpretation.

2. (a) Calculate the amplitude for a massless electron of momentum $p=(p^+,0^-,\boldsymbol{0}_\perp)$ and positive helicity to radiate a photon with momentum $k=(xp^+,k_\perp^2/xp^+,\boldsymbol{k}_\perp)$ and helicity $\lambda=\pm1$. You may use the LF spinors and polarization vectors given on the home page.

(b) Discuss the dependence of the photon polarization on x. Find the relation between the squared amplitude and the splitting function $P_{\gamma/e}(x)=[1+(1-x)^2]/x$.

3. Protons may emit soft photons coherently, *i.e.*, photons with a wavelength longer than the proton radius, which couple to the total charge of the proton.

(a) Estimate the range in transverse momentum and energy of photons coherently emitted by the 7 TeV protons in the LHC. Are they interesting for the LHC experiments?

(b) Evaluate the off-shellness p^2-m^2 of the emitting proton in the process $N(p)\to N(p')+\gamma(k)$. For a given $x=k^+/p^+$, estimate the range of $\boldsymbol{k}_\perp$ in which the off-shellness is independent of the transverse momentum of the photon. From this, determine the effective radius of the photon cloud as a function of x. What is this radius (in fm) at the LHC for photons of 100 GeV?