FYSH560 spring 2011/kevät 2011

Exam Friday March 11, 2011. Koe perjantai 11.3.2011.

Answer in Finnish or English. Vastaa valintasi mukaan suomeksi tai englanniksi.

1. Consider an optical model for scattering off a target potential at high energy. The elastic scattering amplitude is

$$\mathcal{A}(\mathbf{q}_T) = \frac{i}{2\pi} \int \mathrm{d}^2\mathbf{b}_T e^{-i\mathbf{q}_T\cdot\mathbf{b}_T} \Gamma(\mathbf{b}_T),$$

with $\Gamma(\mathbf{b}_T)$ a complex function. The flux factor has now been absorbed into the amplitude.

   (a) What is the physical interpretation of $\Gamma(\mathbf{b}_T)$ and $S(\mathbf{b}_T) = 1 - \Gamma(\mathbf{b}_T)$ when Γ is real? What are they for a "black disk"?

   (b) Calculate the elastic cross section σ_{el} by squaring and integrating over $\mathbf{q}_T$.

   (c) What is the absorption cross section σ_{abs}? (Hint: In $\mathbf{b}_T$ space, if the amplitude of the incoming wave is 1, what is the amplitude of the outgoing wave? To get the intensity from the amplitude Fourier transform from $\mathbf{b}_T$ to $\mathbf{q}_T$ and take the absolute value squared. To get σ_{abs} subtract the intensities of the incoming and outgoing waves and integrate over $\mathbf{q}_T$.). Calculate the total cross section $\sigma_{\mathrm{el}} + \sigma_{\mathrm{abs}}$ and interpret as the optical theorem.

2. Draw an n-rung BFKL ladder diagram (in Finnish rung=tikapuun askelma). What are the effective vertices and propagators (you do not need to remember the exact expressions); how have they been obtained? Label the momenta in the ladder and state the multi-Regge kinematical approximation. What does one get by summing all the BFKL ladder diagrams, i.e. summing over n?

3. (a) How is "diffractive scattering" defined theoretically? What is the experimental signature of diffractive scattering?

   (b) Sketch a diffractive event in a detector at an electron-proton collider such as HERA; identifying the incoming and outgoing particles as far as possible. How does this event differ from a typical inclusive (non-diffractive) DIS event? Interpret *roughly* the scattering angles or rapidities of the outgoing particles in terms of the variables Q^2, $\beta \approx Q^2/(Q^2 + M_X^2)$ and $x_{\mathbb{P}} = x/\beta$. [The definitions of the kinematical variables are $Q^2 = -(k-k')^2$, $x = Q^2/(2P\cdot q)$, $x_{\mathbb{P}} = (P-P')\cdot q/P\cdot q$, but you do not need to calculate explicitly the angles.]