Lund strings, exercises

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1. Show by *explicit calculation* that the property of the *yo-yo mode*:

$$\kappa^2 A = E_{\mathrm{cm}}^2,$$

where A is the total spanned area during one period of oscillation, holds under a longitudinal boost with rapidity y.

2. The *Regge slope* in a classical model for light mesons consisting of a revolving string with massless quarks at the end-points is:

$$\alpha' = \frac{1}{2\pi\kappa}.$$

The slope can be measured in data, and in this way a numerical value for κ can be obtained. Consider now the slope of the Pomeron trajectory. You can treat the Pomeron ($\mathbb{P}$) as a closed string (a double rod approximating a loop). What is the ratio $\alpha'(\mathbb{P})/\alpha'(\text{light meson})$ in this simple, classical model?
Bonus: How does it compare to data (you have to look for data yourself)?

3. Show that the *average breakup-time* of a $\mathrm{q\bar{q}}$ string is given by:

$$\langle \tau^2 \rangle = \frac{1+a}{b\kappa^2},$$

where a and b are the parameters of the Lund fragmentation function. Reasonable values (Pythia defaults) are $a = 0.68$ and $b = 0.98$ GeV^{-2}, which should be inserted to give a number.

4. In this exercise we study breakup probabilities for different quark flavours.

   a The *charm quark mass* ranges between 1.2 and 1.6 GeV, depending on the used approach. Estimate the tunneling suppression for charm (let $\kappa = 1$ GeV/fm ≈ 0.2 GeV^2). Based on the obtained number, would you expect that charm quark breakings should be included or not?

   b Imagine now that the string tension is not constant, but can increase (for example when multiple strings overlap in the rope hadronization model). Let ρ be the suppression of strange quarks to u or d types, and ρ_0 be the value of ρ for a single string, fitted at LEP. At what value of κ is production of strangeness twice than at LEP?