Problem 19: Initial QGP temperature

Under the assumption of entropy conservation during the space-time evolution of a heavy-ion collision one can estimate the initial temperature of the QGP from the measured charged-particle multiplicity $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}y$. In the Bjorken model, the initial entropy density of the QGP at time τ_0 is given by

$$s_{\mathrm{Bj}} = \frac{1}{A\tau_0} k \frac{\mathrm{d}N_{\mathrm{ch}}}{\mathrm{d}y}$$

where the entropy per charged particle is $k \approx 7.2$. A is the transverse area.

a) Plot the initial temperature of the QGP as a function of τ_0 for central Pb–Pb collisions at the LHC ($\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}y \approx 1800$, $R_{\mathrm{Pb}} = 6.62\,\mathrm{fm}$). Use a degeneracy factor $g_{\mathrm{QGP}} = 42.25$ corresponding to 2.5 active quarks flavors.

b) What is the initial temperature for $\tau_0 = 1\,\mathrm{fm}/c$?

Problem 20: Dissociation temperatures

When the screening mass $\mu(T)$ of the QGP reaches a critical value μ_{D}, the corresponding quarkonium state cannot form in the QGP (take $\mu_D = 0.699, 0.357, 1.565, 0.671\,\mathrm{GeV}$ for J/ψ, ψ', $\Upsilon(1S)$, $\Upsilon(2S)$, respectively). The screening mass is approximately given by

$$\mu(T) = \sqrt{1 + \frac{n_f}{6}} g(T/T_c) T$$

where the coupling g is given by

$$g^2 \left(\frac{T}{T_c}\right) \approx \mathrm{const} = \frac{48\pi^2}{(33 - 2n_f)\ln(F^2)}, \quad F \approx 35.$$

Assume three active quarks flavors ($n_f = 3$).

a) Plot $\mu(T)$ as a function of T/T_c along with the μ_D values of the four quarkonium states.

b) Calculate the dissociation temperature T_D/T_c of the four states.