Tutorial sheet 11

Discussion topic: Hadrochemistry: what is strangeness enhancement? the idea of the statistical model of hadron production?

Throughout the exercise sheet, a system of units such that the constants c, $\hbar$ and k_B equal 1 is used.

22. Kaon-to-pion ratio

Consider a system of u, d, s quarks and their antiquarks, whose respective amounts are denoted N_u, N_d, N_s and so on. This system is supposed to "hadronize" fully into a system of pions (π^+, π^-, π^0) and kaons (K^+, K^-, K^0, $\overline{K^0}$), such that equal amounts of each species in a family are produced: $N_{\pi^+} = N_{\pi^-} = N_{\pi^0}$ and a similar equality among the four kaon species.

Express the ratio N_{K^+}/N_{π^+} as a function of the numbers of quarks and antiquarks.

23. Canonical suppression factor

Fill the gaps in the lecture: on slides 27–30 of the "Hadrochemistry" lecture, a number of technical calculations were left aside. Starting from the single-particle partition functions z_+, z_-, z_s of K^+, K^- and a hadron species with strangeness $S = s$ (hereafter: "hyperons"), compute the average number $\langle N_s \rangle$ of hyperons in the grand canonical and the canonical ensembles and deduce the canonical suppression factor of the hyperons.

24. Ratios of light nuclei in the statistical model

i) Calculate the ratio $\mathrm{d} : {}^3\mathrm{He} : {}^4\mathrm{He}$ of the yields of deuterons, ^{3}He, and ^{4}He nuclei in the statistical model for $T = 156.5$ MeV and vanishing chemical potentials μ_B and μ_{I_3} (nuclear masses: $m_d = 1.8756$ GeV, $m_{^3\mathrm{He}} = 2.8084$ GeV, $m_{^4\mathrm{He}} = 3.7274$ GeV).

ii) Plot the particle density n per spin degree of freedom as a function of the mass m for $T = 156.5$ MeV: a) taking quantum statistics into account; b) in the Boltzmann approximation; c) in the Boltzmann approximation using the leading order of the large-argument approximation of the modified Bessel functions of the second kind [see exercise **19.iii)**]. What do you conclude?