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Probing Hadronization with Strangeness

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Abstract. The $\overline{\Omega}/\Omega$ ratio originating from string decays is predicted to be larger than unity in proton-proton interaction at SPS energies. The anti-omega dominance increases with decreasing beam energy. This surprising behavior is caused by the combinatorics of quark-antiquark production in small and low-mass strings. Since this behavior is not found in a statistical description of hadron production in proton-proton collisions, it may serve as a key observable to probe the hadronization mechanism in such collisions.

Keywords: hadronization, statistical models, string fragmentation
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1. Introduction

Hadron yields and their ratios stemming from the final state of ultra-relativistic heavy-ion collisions have been extensively used to explore the degree of chemical equilibration [1–10] and to search for evidence for exotic states and phase transitions in such collisions [1]. Under the assumption of thermal and chemical equilibrium, fits with a statistical (thermal) model have been used to extract bulk properties of hot and dense matter, e.g. the temperature and chemical potential at which chemical freeze-out occurs [5–9].

The application of a statistical model to elementary hadron-hadron reactions was first proposed by Hagedorn [11] in order to describe the exponential shape of the m_t-spectra of produced particles in p+p collisions. Recent analyses [12] on hadron yields in electron-positron and proton-proton interactions at several centre-of-mass energies have shown that particle abundances as well can be described by a statistical ensemble with maximized entropy. In fact, the abundancies are consistent with a model assuming the existence of equilibrated fireballs at a temperature $T \approx 160 - 170$ MeV. These findings have given renewed rise to the interpretation that hadronization in elementary hadron-hadron collisions is a purely statistical process, which is difficult to reconcile with the popular dynamical picture that hadron production in pp collisions is due to the decay of color flux tubes [13].

In this article we argue that the $\overline{\Omega}/\Omega \equiv \Omega^+/\Omega^-$ ratio in elementary proton-proton collisions is an unambiguous and sensitive probe to distinguish between particle production via the breakup of a color flux tube from statistical hadronization [14].

2. (Anti-)baryon production in sting models

Color flux tubes, called strings, connect two SU(3) color charges [3] and [$\overline{3}$] with a linear confining potential. If the excitation energy of the string is high enough it is allowed to decay via the Schwinger mechanism [15], i.e. the rate of newly produced quarks is given by:

$$\frac{\mathrm{d}N_\kappa}{\mathrm{d}p_\perp} \sim \exp\left[-\pi m_\perp^2/\kappa\right] \qquad (1)$$

where κ is the string tension and $m_\perp = \sqrt{p_\perp^2 + m^2}$ is the transverse mass of the produced quark with mass m.

However, specific string models may differ in their philosophy and the types of strings that are created:

- In UrQMD[16] the projectile and target protons become excited objects due to the momentum transfer in the interaction. The resulting strings, with at most two strings being formed, are of diquark-quark type.
- In NeXuS[17], the pp interaction is described in terms of pomeron exchanges or ladder diagramms. Both hard and soft interactions happen in parallel. Energy is shared equally between all cut pomerons and the remnants. The endpoints of the cut pomerons (i.e. the endpoints of the strings) may be valence quarks, sea quarks, antiquarks or gluons.