VI
Strangeness

17 Thermal production of flavor in a deconfined phase

17.1 The kinetic theory of chemical equilibration

Strangeness, and more generally heavy-flavor quarks, can be produced either in the first interactions of colliding matter, or in the many ensuing less-energetic collisions. The mass of the strange quark $m_{\rm s}$ is comparable in magnitude to the typical temperatures reached in heavy-ion interactions, and the numerous 'soft' collisions of secondary partons dominate the production of strangeness, and naturally, of the light flavors u and d.

The masses of charm and bottom quarks are well above typical temperatures; these quarks are predominantly produced in the hard initial scattering. This process remains today a topic of current intense study both for the elementary and for the nuclear collisions [124]. We will not discuss it further in this book.

At the time at which the strange flavor approaches chemical equilibrium in soft collisions, the back reaction is also relevant. The quantum-mechanical matrix element driving a two-body reaction must be, channel by channel, the same for forward- and backward-going reactions. The actual rates of reaction differ since there are usually considerable differences in statistical and phase-space factors. However, the forward and backward reactions will balance when equilibrium yields of particles are established. This principle of detailed balance can sometimes be used to evaluate reaction rates.

The net change in yield of flavors f and $\bar{\rm f}$ is given by the difference between the rates of production and annihilation. The evolution in the density of heavy quarks in QGP can be described by the master equation

$$\frac{dN_{\rm f}(t)}{d^3x\,dt} = \frac{dN({\rm gg, q\bar{q}} \to {\rm f\bar{f}})}{d^3x\,dt} - \frac{dN({\rm f\bar{f}} \to {\rm gg, q\bar{q}})}{d^3x\,dt}. \tag{17.1}$$