Multiparticle Production from the Color Superconducting Quark Matter

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We investigate multiple production of hadrons in the high-energy heavy-ion collisions. It is assumed that the high-density quark matter is formed in the central region in those collisions from which many baryons, mesons and anti-baryons are produced. These hadrons seem to reflect the property of the high-density quark matter. If the quark matter is in the color superconducting phase, the distribution of the ejected hadrons will be affected by the color superconductivity. It is the purpose of this work to study the distribution of multiple production from the color superconducting quark matter.

We consider the quark matter with chemical potential μ and temperature T. The total particle numbers of quarks and anti-quarks are denoted by N_q and $N_{\bar{q}}$ respectively. Such a high-density and hot quark matter will decay into many hadrons, which are N_b baryons, $N_{\bar{b}}$ anti-baryons and N_m mesons. Our essential assumption is that the ratio of these numbers is determined by combinatorics of quarks and anti-quarks;

$$N_b : N_{\bar{b}} : N_m = \frac{2}{3}{}_{N_q}C_3 : \frac{2}{3}{}_{N_{\bar{q}}}C_3 : N_q N_{\bar{q}}, \tag{1}$$

where ${}_nC_N$ represents a binomial coefficient and color singlet condition for hadrons is taken into account.

If the quark matter is in color superconducting phase, the above relation should be modified. Let us denote numbers of Cooper pairs of quarks and anti-quarks by n_q and $n_{\bar{q}}$ respectively. Two particles in the Cooper pair always move together so that they will decay into a baryon (anti-baryon). Therefore we have the following modified equation,

$$N_b : N_{\bar{b}} : N_m = (n_q N_q^{\theta} + \frac{2}{3}{}_{N_q^{\theta}}C_3) : (n_{\bar{q}} N_{\bar{q}}^{\theta} + \frac{2}{3}{}_{N_{\bar{q}}^{\theta}}C_3) : N_q^{\theta} N_{\bar{q}}^{\theta}, \tag{2}$$

where $N_q^{\theta} = N_q - 2n_q$ and $N_{\bar{q}}^{\theta} = N_{\bar{q}} - 2n_{\bar{q}}$ correspond to the numbers of the unpaired quarks and anti-quarks respectively. This equation means that the production rates of both baryons and anti-baryon are enhanced due to the color superconductivity or pairing effect. On the other hand, that of mesons is suppressed. Then our results are compared with the data obtained in the BNL Relativistic Heavy Ion Collisions (RHIC).

Finally we will discuss that such an enhancement is also expected in the hot quark matter above the critical temperature. It is caused by the collective (soft) mode, which is well known as a precursor of the color superconductivity.

References

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