Charged particle production in pp and heavy ion collisions

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Introduction

The most abundant particles produced in pp and heavy ion collisions at RHIC and LHC energies are the light hadrons. The transverse momentum (p_T) spectra of hadrons can be used to describe the particle production in pp collisions. Final state effects such as collective flow, recombination and jet quenching in different p_T ranges are applicable in heavy ion collisions. To explain the collective flow and energy loss effects, the modified Tsallis distribution function is proposed.

Modified Tsallis Distribution Function

The Tsallis distribution can describe the p_T spectra in pp collisions at all pp colliders. Several functional form of Tsallis distribution including the transverse collective flow are available for the description of the p_T spectra in heavy ion collisions. In the present work, the p_T spectra at high p_T in heavy ion collisions are modified due to in-medium energy loss. The p_T spectra of charged particles can be described using the modified Tsallis distribution function including the final state effects in different p_T regions. The modified Tsallis function is given by [1]

$$E\frac{d^3N}{dp^3} = \begin{cases} f_1(p_T) & : p_T < 7 \text{ GeV/c.} \\ f_2(p_T) & : p_T > 7 \text{ GeV/c.} \end{cases} \quad (1)$$

Here

$$f_1(p_T) = A_1\left[\exp\left(-\frac{\beta p_T}{p_1}\right) + \frac{m_T}{p_1}\right]^{-n_1}.$$

$$f_2(p_T) = A_2\left[p_T^{\alpha} + \frac{m_T}{p_2}\right]^{-n_2}.$$

The first function $f_1(p_T)$ governs the thermal and collective behaviour of the hadron spectra with the temperature $T = p_1/n$ and the average transverse flow velocity β. The second function $f_2(p_T)$ governs the energy loss behaviour. In $f_2(p_T)$, the Tsallis function includes the term $p_2\, p_T^{\alpha}$, where the parameter p_2 is proportional to the medium size and the parameter α quantifies the different energy loss regimes for light quarks in the medium.

Results and Discussions

Figure 1 shows the p_T of the charged particles as a function of p_T for pPb and PbPb collisions at $\sqrt{s_{NN}}$= 5.02 TeV measured by the CMS experiment [2, 3]. The solid curves are the modified Tsallis distributions.

Figure 2 shows the ratio of the data and the fit function by the modified Tsallis distribution as a function of p_T for pp, pPb and PbPb collisions at $\sqrt{s_N}$= 5.02 TeV. The ratio of the data and the fit function shows that the modified Tsallis function gives good description of the data in full p_T range for all systems. The parameters are given in the Table I and II. The parameters n_1, p_1 and β increases with increasing size for PbPb collisions. It shows that the degree of thermalization (governed by n_1) and the transverse flow (governed by β) increases with system size. The value of the parameter $n_2 (= 7.7)$ is guided by the pp value. The exponent α describes the variation of the energy loss of partons as a function of their energy remains within 0.4 to 0.6. The parameter p_2 is proportional to the system size and increases as we move from pp to the most central PbPb collisions. The modified function gives excellent description of hadron spectra over wide range of p_T with its param-

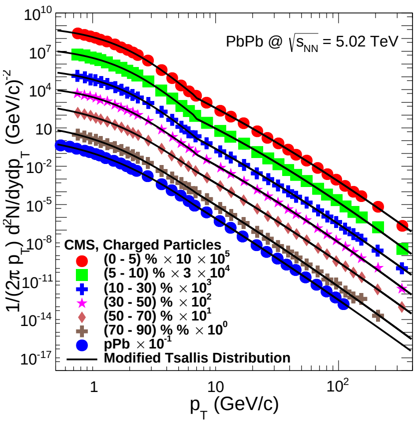

FIG. 1: The invariant yields of the charged particles as a function of p_T for pPb and PbPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV measured by the CMS [2, 3]. The solid curves are the modified Tsallis distribution function.

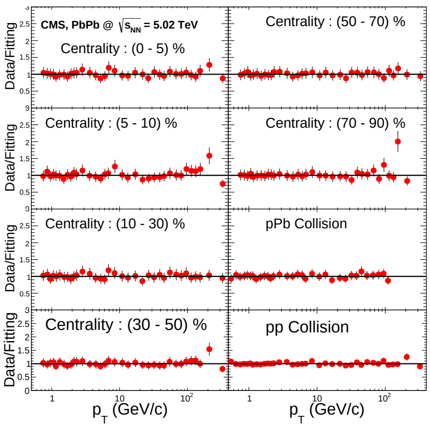

FIG. 2: The ratio of the charged particle yield data and the fit function as a function of p_T for pp, pPb and PbPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV.

eters indicating different physics effects in the collisions.

Conclusion

The modified Tsallis function includes transverse flow in low p_T region and in-medium energy loss in high p_T region. This

TABLE I: The parameters of the modified Tsallis function.

System	n_1	p_1 (GeV/c)	β
PbPb 0-5 %	8.07 ± 0.74	1.36 ± 0.13	0.67 ± 0.06
PbPb 5-10 %	7.98 ± 0.76	1.36 ± 0.13	0.66 ± 0.08
PbPb 10-30 %	7.79 ± 0.83	1.30 ± 0.15	0.61 ± 0.09
PbPb 30-50 %	6.99 ± 0.54	1.13 ± 0.09	0.68 ± 0.08
PbPb 50-70 %	6.78 ± 0.75	0.98 ± 0.13	0.47 ± 0.08
PbPb 70-90 %	6.52 ± 0.87	0.88 ± 0.17	0.38 ± 0.05
pPb	7.78 ± 1.70	1.34 ± 0.95	0.14 ± 0.05
pp	7.43 ± 1.56	1.09 ± 0.48	0.14 ± 0.05

TABLE II: The parameters of the modified Tsallis function.

System	n_2	p_2 (GeV/c)$^{(1-\alpha)}$	α
PbPb 0-5 %	7.70	5.73 ± 0.22	0.48 ± 0.04
PbPb 5-10 %	7.70	5.56 ± 0.34	0.40 ± 0.04
PbPb 10-30 %	7.70	4.94 ± 0.20	0.49 ± 0.04
PbPb 30-50 %	7.70	4.20 ± 0.25	0.46 ± 0.05
PbPb 50-70 %	7.70	3.68 ± 0.16	0.57 ± 0.05
PbPb 70-90 %	7.70	2.90 ± 0.16	0.58 ± 0.07
pPb	7.70	3.32 ± 0.74	0.66 ± 0.08
pp	7.70	2.87 ± 0.10	0.60 ± 0.04

function gives good description of the charged particle spectra in pp, pPb and PbPb collisions with its parameters having potential to quantify various in-medium effects.

References

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