# A comprehensive study on the influence of partonic and hadronic scattering on the effective temperature ($T_{eff}$) using the AMPT model

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## Introduction

Under extreme conditions of temperature and/or baryon density, hadronic matter undergoes a phase transition to produce a new state of matter known as quark-gluon plasma (QGP) [1]. Relativistic heavy-ion collision is the only way to produce such hot and dense nuclear matter in the laboratory. Over the past few decades several indirect signatures of QGP were proposed such as $J/\psi$ suppression [2], strangeness enhancement [3], jet-quenching [4] etc. Multitudes of particles produced in different stages of the collision may carry all important information regarding the evolution of the nuclear matter after production. The observables of heavy-ion collisions are mainly categorized into three categories: soft probes or global observables, hard probes and electromagnetic probes. The global observables include rapidity, pseudorapidity and transverse momentum distributions. Roughly 95% of the total particles produced are due to soft processes. Transverse momentum distribution is believed to be one of the important observable of heavy-ion collision as it reflects the kinetic freeze-out temperature as well as the radial flow of the produced matter. Hence, it is quite worthy to study the bulk properties of the system in terms of transverse momentum ($p_T$) or transverse mass ($m_T$) distributions. Several experiments such as E866, NA44, NA49 already studied the transverse mass distribution of the produced hadrons at AGS to SPS energies [5–8]. The transverse mass spectra of produced hadrons can be parameterized using the Boltzmann function,

$$\frac{1}{m_T}\frac{dN}{d\,m_T} \sim exp\left( - \frac{m_T}{T_{eff}}\right), \qquad (1)$$

where, $T_{eff}$ is known as effective temperature. The quantity $T_{eff}$ contains two components: the actual temperature at kinetic freeze out ($T_f$) and the collective transverse flow ($\beta_T$).

In the present work, we explore the energy dependence of the effective temperature for a few mesons and baryons by simulating Pb+Pb collisions using the string melting version of the AMPT model [9]. In string melting configuration of the AMPT model, both partonic and hadronic interactions are the major ingredients. In the present work an attempt has been made to study the influence of hadronic and partonic interaction on the effective temperature.

## Results and discussion

The transverse mass spectra of the mesons ($K^+, K^-, \phi$) and baryons ($p, \Lambda, \Xi^-$) produced in central (0-20%) Pb+Pb collisions are fitted using Eq. 1 for $20, 30, 40, 80, 158$A GeV. The values of the effective temperatures obtained from the Boltzmann fitting for parton scattering cross-section $\sigma = 3\,$mb with NTMAX = 3 and NTMAX = 150 are plotted in Fig. 1. It is to be highlighted that the numerical values of $T_{eff}$ at 10 mb parton scattering cross-section with NTMAX = 150 are taken from the Ref. [10]. In AMPT, the value of the parameter NTMAX = 3 virtually stops hadron scattering, and the default value i.e. NTMAX = 150 corresponds full time scale for hadron cascade.

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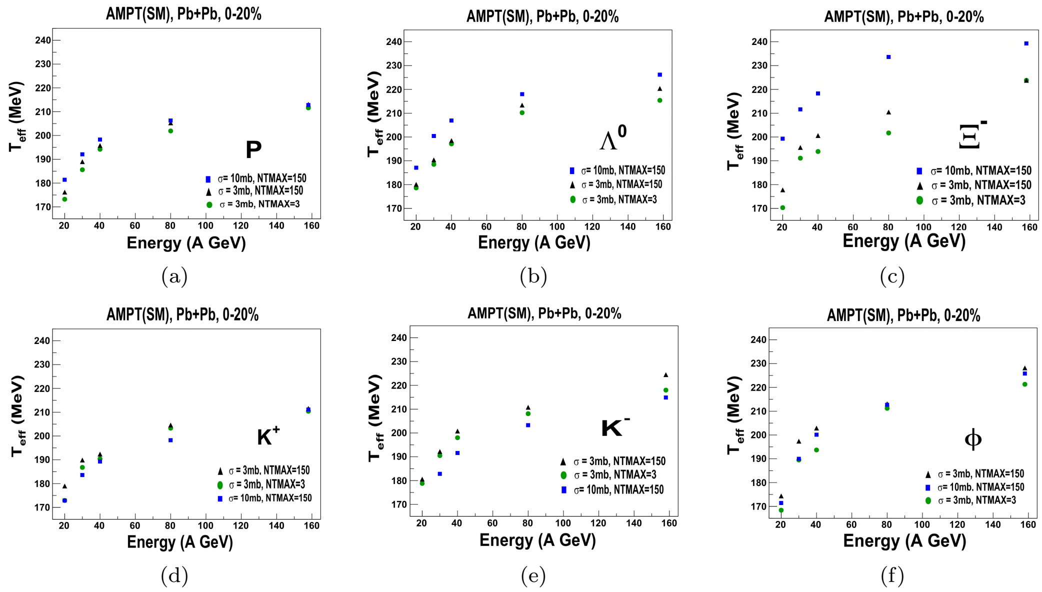


FIG. 1: The plot of $T_{eff}$ against different energies for studied baryons and mesons.

It is clearly seen from the figure that the effective temperatures are different for different parton scattering cross-sections indicating the role of partonic phase in the development of collective flow. In addition to this, it is seen that for baryons $(p, \Lambda, \Xi^-)$, the effective temperatures at 10 mb parton scattering cross section are larger than 3 mb parton scattering cross section [see Figs. 1(a), 1(b) and 1(c)]. But the mesons $(K^+, K^-, \phi)$ the trend is completely opposite i.e. the effective temperature at 3 mb parton scattering cross-section is larger than that of 10 mb parton scattering cross-section [see Figs. 1(d), 1(e), 1(f)]. This observation indicates that the collective flow achieved due to the partonic phase is different for mesons and baryons. We also find that the effect of parton scattering on $T_{eff}$ is larger than that of the hadronic scattering making $T_{eff}$ to be an interesting observable to study the role of partonic phase in heavy-ion collisions.

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