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Beyond the thermal model

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The statistical hadronization (or thermal) model was initially developed by Hagedorn for hadron collisions above 10 GeV/c primary laboratory momentum [1]. In relativistic heavy-ion physics, many authors have developed it further and compared to a large amount of data in particular for hadron production rates, e.g. [2,3,4], where it yields excellent results.

To decide whether the system is indeed in thermal equilibrium, the distribution functions rather than production yields are decisive:
In the transverse momentum distributions of produced particles, deviations from thermal behaviour plus collective expansion occur beyond about 8 GeV/c. Not only the rapidity distributions of net baryons, but also the pseudorapidity distributions of produced mesons deviate from pure thermal behaviour: the thermal model does not generate a plateau in dN/dy, or a dip in dN/deta.

Such non-equilibrium effects can to a certain extent be accounted for in a relativistic diffusion model [5,6] with three sources - two fragmentation sources, and a mid-rapidity source arising from gluon-gluon collisions - that merges with the thermal model only for time to infinity. Given the short interaction times of AuAu at RHIC or PbPb at LHC, the fragmentation sources still contribute substantially, providing good results when compared [6,7] to data from PHOBOS and ALICE, and also for asymmetric systems such as dAu at RHIC and pPb at LHC.

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