HEAVY FLAVOURS PRODUCTION IN QUARK-GLUON PLASMA
FORMED IN HIGH ENERGY NUCLEAR REACTIONS

J. KLOSINSKI [*]

RIVERS STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY
Physics Department
P.M.B. 5080
Port Harcourt, Nigeria

A B S T R A C T

Results on compression and temperatures of
nuclear fireballs and on relative yield of
strange and charmed hadrons are given in this
paper. The results show that temperatures above
300 MeV and large compressions ($\gtrsim$ 10) are unlikely
achieved in average heavy ion collision. In
consequence thermal production of charm is low.
Strange particle production is, however, substan-
tial and indicates clear temperature - threshold
behaviour.

1. <u>Introduction</u>: Observation of QGP is one of the most
desired arguments in favour of correctness of our understan-
ding of strong interactions. Its formation needs a large
deposition of energy in large enough volume. The intera-
ctions of cosmic ray particles, primarily nuclei, offer the
unique opportunity of its detection.

One of the signatures of QGP formation is increased
rate of heavy flavours as compared to the hadronic systems
at the same temperature without QGP formation (1). The
role of charm may be also peculiar; we forsee charmed
quarks as a centers of hadronic buble formation in hot QGP
and as a stabilizing factor in cold multicharmed globs (2).
Both phenomena may lead to unusual events. Here we
present only some of our results. The full paper will be
published elsewhere.

2. <u>The model</u>: Several arguments, based on experimental
observations (the transparency of nuclei being strongest
one) and on results of relativistic of two fluid - hydro-
dynamics allows us to treat the beam nucleus (for
definitness we will work in the lab frame) as a penetra-
ting, shock-like discontinuity propagating with (almost)
velocity of light through the nuclear matter. In
equations of hydrodynamics its propagation is represented

as a source term of energy, momentum and colour (but not
baryon number) transferred to the nuclear matter. These
equations allow us to find (with assumed equation of state
for nuclear matter) the heating curve i.e. temperature T
and compression factor $f (= n_B/n_0, n_0 = 0.17/fm^3)$ behind
the front. Whenever T and f are in QGP sector of QGP-
hadron phase diagram we assume that, within the slice
1-2 fm behind the traversing beam nuclei thermalized QGP is
formed.

We tried several models of nuclear matter to get
equation of state, but finally our results represented here
are based on Walecka mean field model, Statistical boot-
strap model of point particles, and Hybrid model of free
N, Δ, π - gas with phenomenological repulsion potential
fitted at low energies. The qualitatively the results for
all models are the same.

QGP is described by standard model of four fermions
(u,d,s, c - quarks) and eight bosons (massless gluons).
The parition function with several sets of parameters
tried, has been calculated up to the lowest order of pertur-
bative expansion. The masses and coupling constant are
taken density and temperature dependend with the running
momentum $q = ((2T)^2 + (\mu_B/3)^2)^{\frac{1}{2}}$.

The evolution of QGP (its expansion and flow) is
governed by hydro-and thermodynamics. One of the strongest
constraints is given by baryon number conservation and
entropy production condition (1), (3): i.e. surface
hadronic deflagration of QGP at thermal and chemical
equilibrium is forbiden prior to the reversed phase transi-
tion QGP-Hadronic gas. In consequence all hadrons are
produced at transition temperature, which (for $f \lesssim 10$) is
roughly 160-180 MeV and, as entropy production in deflagra-
tion is low, they preserve degrees of freedom of QGP close
to the transition.

3. Results: Our model gives a unique possibility to
relate T and f when equation of state is given. According
to the authors knowledge this result is unique and original
(4). In the approximations used the result for T(f) do not
depend on size of the neither beam not target nuclei. The
result for assumed (ud), (uds), (udsc) QGP is presented on
Fig. 1.

The second result of our model which we wish to
present to the Conference is strangeness and charm
relative yield when QGP is formed in nuclear collision.
Due to high entropy per baryon and, in principle, unlimited
temperature as well as due to peculiar properties of QGP
evolution its presence offers more abundant production of
heavy flavours than any hadronic process without QGP.

Due to the finite relaxation times the production of heavy flavours at lower temperatures is damped by finite life time of QGP. In consequence the production of strangeness and charm displays a pronounced temperature-threshold enhancements. For nuclear fireball created according to the our scenario the strange particles start to be copiously produced at T $\gtrsim$ 240 MeV, (see Fig. 2) whereas charmed particles have threshold at T $\approx$ 500 MeV.
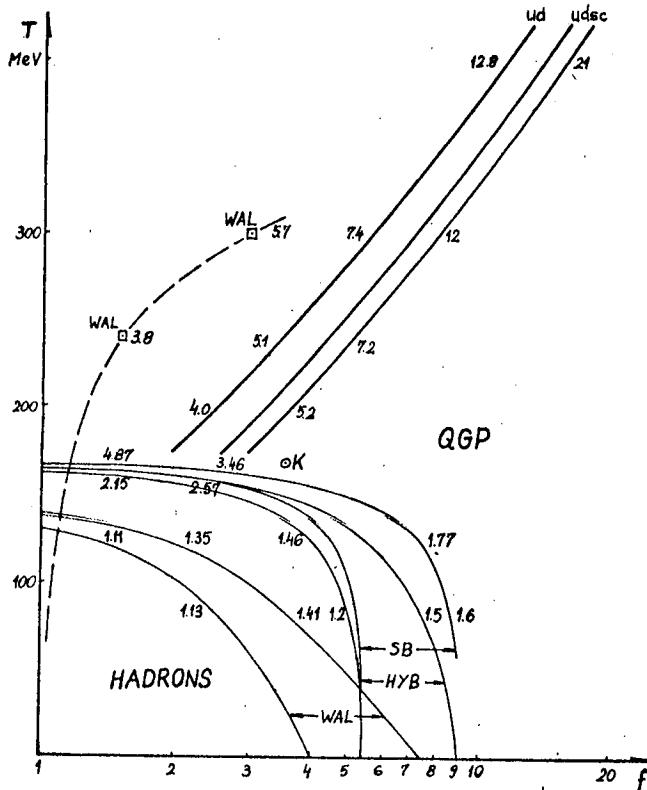

Fig. 1

Temperature T and compression factor (f) of nuclear fire-ball together with phase diagram for Walecka (WAL), Hybrid (HYB) and stat. Bootstrap (SB) models of hadronic gas.

T-f curve for hadronic fire-ball has been got for ud, uds and udsc flavours. WAL-curve has been got when com-pressed matter is assumed to be Walecka nuclear matter. K is "Kajantie point". All numbers refer to energy per baryon.

4. <u>Conclusions</u>: According to our model and within the approximations done our results indicates:

   (i) High temperatures in nuclear fireballs are not likely to be common phenomenon at high energy interactions. It is relatively easy to heat nuclear fire-ball up to T = 200 ~ 240 MeV.
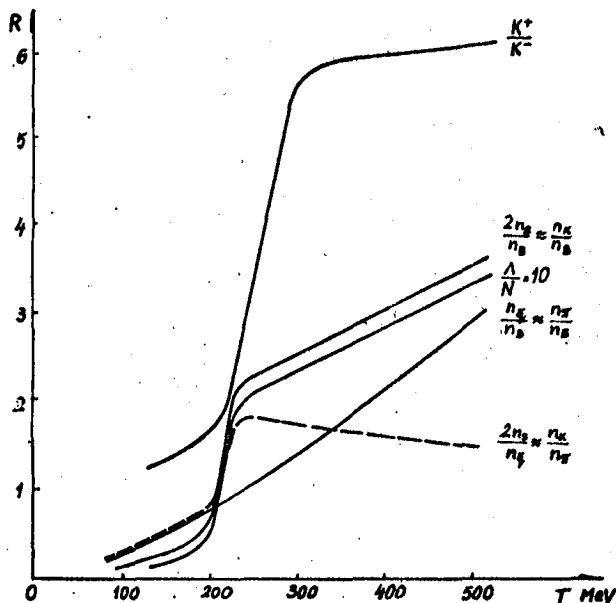
Fig. 2
Ratio R of strange quarks and hadrons yield v.s. initial temperature of nuclear fireball. The threshold behaviour is seen only for strange hadron yield but not for nonstrange component. For charmed particles yield similar threshold is expected for temperatures above 500 MeV.

(ii) Nuclear fireball decays in a deflagration - like process at T = 160-180 MeV when almost all hadrons are produced.

(iii) Heavy flavours are easily produced provided relaxation time is shorter than life time of QGP droplet. Their production displays threshold - like enhancement which may serve as indicator of QGP-formation.

(iv) Energy transferred to heavy flavour component is almost steady ($\approx$ 30%) fraction of total energy.

(v) Charmed quarks and consequently charmed particles are produced in very low amount (at T = 500 MeV n_C/n_B is $\approx 10^{-6}$).

References:

1. Quark matter Formation, Ed. M. Jacob, H. Satz: Singapore, 1982.

2. J. Klosinski, Proc. of 18th ICRC, Vol.II, p. 166.

3. L. Van Hove, Z, Phys. C, 21, (1983) 93-98.

4. R. Anishetty et al, Phys. Rev. 22 (1980) 2793.