Resonances from a Hadronic Fireball

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Abstract. Production of $\phi(1020)$, $\Lambda^*(1520)$ and $\overline{K}^*(892)$ resonances at the final stage of a heavy-ion collision is considered. It is shown that original momentum distributions and abundance of resonances formed during the process of heavy ion collision may differ significantly from their measured spectra and yields. Reconstruction probability of resonances decaying inside the fireball can be strongly suppressed because of interactions of their hadronic decay products in the fireball medium. We investigate dependence of the degree of the suppression on the fireball size, dynamics, and the resonance decay width in medium. Quantitative results are presented for lead-lead collisions at 158 GeV SPS beam energy.

1. Introduction

Present experimental information available in the field of heavy-ion collisions allows for the systematic investigation of strongly interacting hadronic matter under extreme conditions. High statistics accumulated in various experiments facilitates reconstruction of hadronic resonances via their decay products. At CERN-SPS experiments several resonances have been identified so far: $\phi(1020)$ mesons are detected by NA49 collaboration via $\phi \rightarrow K^+K^-$ decay [1] and by NA50 via $\phi \rightarrow \mu^+\mu^-$ channel [2], $\Lambda^*(1520)$ and $\overline{K}^*(892)$ are seen by NA49 in their dominant decay modes [3, 4, 5], the $\rho$ and $\omega$ mesons are measured by NA50 in dimuon channel [6]. Already the first preliminary data were surprising. Total averaged $\phi$ meson multiplicity extracted from NA49 data was found to be significantly smaller than that obtained from the extrapolation of preliminary NA50 data. Another interesting observation is that preliminary NA49 data on $\Lambda^*(1520)$ multiplicity reveal significant suppression of the yield per participating nucleon when compared to inelastic proton-proton collisions. This contradicts to systematics of other strange particle abundance at SPS energies.

Suggested explanation of the $\phi$-meson puzzle [7] was that $\phi$-mesons decaying inside a fireball can disappear from the $K^+K^-$ mass peak due to rescattering and absorption of secondary kaons in the surrounding medium. Such mechanism has been quantitatively studied in [8] where suppression at the level 40–60% has been obtained from simulation using RQMD code. Similar mechanism could also account for $\Lambda^*(1520)$ suppression. In [9] 75% suppression for $\phi(1020)$ and 50% for $\Lambda^*(1520)$ particles have been obtained.
Resonances from a Hadronic Fireball

within UrQMD model. Therefore the rescattering of resonance decay products can indeed explain in part some experimental observations. However, besides the lack of quantitative account of the difference in the extrapolated $\phi$ meson yields, other caveat has been issued in [10]: Since the vacuum width of $K^*(892)$ mesons is more than 3 times larger than the $\Lambda^*(1520)$ width, $K^*(892)$ mesons decay inside a fireball more frequently and should be therefore suppressed even stronger than $\Lambda^*(1520)$. The preliminary data of NA49 [4] do not show such a suppression for $K^*(896)$.

In this paper we discuss to what extent the in-medium modifications of the resonance decay width can effect the resonance suppression and help to accommodate empirical information.

2. Global picture of a collision

In our study we consider a two-stage picture of the hadronic phase of heavy-ion collision at SPS energies which can be characterized by the notions of chemical and thermal freeze-outs [11, 12, 13]. At the initial stage of the hadronic phase we assume the temperature $T$ to be close to the QCD phase transition temperature $T_c \approx 170 \pm 10$ MeV. Then the system expands up to the point, when numbers of different kinds of particles freeze in a chemical freeze-out. Thermodynamical parameters of this stage could be obtained by fitting the final total hadron multiplicities. Typical temperature is found to be $T_{\text{chem}} \sim 160 \pm 10$ MeV [11, 12]. During the second stage of collision, elastic scattering processes change momentum distributions of hadrons in accord with a decreasing temperature until they cease and distributions freeze in. The freeze-out temperature can be extracted from a simultaneous fit to the single-particle $m_T$-spectra of different particles supplemented by the analysis of particle correlation data. Typical temperatures are found to be $T = T_{\text{therm}} \sim 110 \pm 30$ MeV [13].

The key assumption behind the decay product rescattering (DPR) mechanism of [7] is that the final resonance distribution is formed at some stage between the chemical and thermal freeze-out. At this moment, mean free paths of the resonance, $\lambda_r$, pions, kaons and nucleons, $\lambda_{\pi,K,N}$, and the characteristic size of the fireball, $R$, should satisfy

$$\lambda_{\pi}, \lambda_{K}, \lambda_{N} \ll R \ll \lambda_{r}.$$  \hspace{1cm} (1)

This implies that upon this stage resonances stream freely out from the fireball. For their decay products, pions and kaons, on the other hand, the surrounding medium is still opaque. Therefore, if a resonance decays inside a fireball in hadronic channel, the decay products can be rescattered or absorbed, so that the resonance remains unobserved experimentally. It is now obvious that the possible increase of a resonance decay width in medium will enlarge the probability of its decay inside a fireball enhancing thereby the DPR mechanism. Besides the total decay width of the resonance and the typical size of the fireball, one of the crucial parameters controlling the efficiency of the DPR mechanism is, the life time of the fireball after the resonance freeze-out, $\tau_{f.o.}$. 


3. Apparent resonance distribution

We denote the phase-space distribution of the resonance \((r)\) in the center-of-mass system of two colliding nuclei at the moment of its thermal freeze-out as \(f^{(r)}(\vec{x}, \vec{p})\). Then the primary momentum distribution of the resonance is

\[
\eta^{(r)}_0(p) = \langle 1 \rangle, \quad \langle \ldots \rangle = \int \Sigma d^3\sigma^\mu p_\mu f^{(r)}(\vec{x}, \vec{p})\langle \ldots \rangle.
\]  

(2)

where integration goes over the fireball volume within a freeze-out hyper-surface \(\Sigma\). In the absence of any in-medium modification of the resonance and res cattering of its decay products, the shape of the momentum distribution observed in the decay channel \(j\) is given by

\[
\eta_j^{(r)}(p) = \Gamma_j^{(r)} / \Gamma_j^{(r)0},
\]

where \(\Gamma_j^{(r)}\) and \(\Gamma_j^{(r)0}\) are the partial and total decay widths of the resonance, respectively. Accordingly, in the experimental analysis, the resonance distribution would be reconstructed from momentum distribution of decay products multiplied by the corresponding inverse branching ratio.

Taking into account modifications of partial and total widths of the resonance and the rescattering of decay products in medium we write expression for the observed resonance distributions in the decay channel \(j\) in the following form

\[
\eta_j^{(r)}(p) = \left\langle D(\tau) + \frac{\Gamma_j^{(r)0}}{\Gamma_j^{(r)0}} \int_0^\tau dt D(t) \Gamma_j^{(r)*}(t) \mathcal{P}_{j\lambda}^{(r)}(t) P_{\text{rec}} \right\rangle.
\]  

(3)

Here

\[
D(t) = \exp \left[ -\int_0^t \Gamma_j^{(r)*}(t') dt' \right],
\]  

(4)

is the probability that resonance will fly for a time \(t\) starting from a position \(\vec{x}\) where it suffers the last interaction. \(\Gamma_j^{(r)} = \Gamma_j^{(r)0} m_r / E_r\) is the total width of a moving particles with energy \(E_r = (m_r^2 + p^2)^{1/2}\), where \(m_r\) is a resonance mass. Here and below asterisk denotes in-medium values of the quantities, which is determined by the current local temperature and density. The probability of the decay products to leave fireball without any rescattering is \(\mathcal{P}_{j\lambda}^{(r)}\). For the explicit form of \(\mathcal{P}_{j\lambda}^{(r)}\) we refer to Ref. [14], where it is written for the case of the two-particle decay. The quantity \(P_{\text{rec}}\) stands for the probability to identify a resonance from non-rescattered decay product. Without in-medium effects we put \(P_{\text{rec}} = 1\) assuming an ideal detector. If spectra of resonance decay products differ in medium from the vacuum ones, the momenta of secondary particles will change on the way out from the fireball even without being rescattered, since in this case a fireball serves as a potential well. This effect can be especially strong for strange resonances since the properties of kaons in the final state are strongly modified in nuclear matter or/and isospin asymmetrical pion gas [16, 17, 18]. For a rough estimation of the maximal suppression effect we put in this case \(P_{\text{rec}} = 0\). The time scale \(\tau\) in (3) is the time spent by the resonance in medium. It is given by

\[
\tau = \min\{\tau_r(\vec{v}, \vec{x}), \tau_{\text{f.o.}}\},
\]

where \(\tau_r(\vec{v}, \vec{x})\) is the time during which the resonance with a velocity \(\vec{v}\) flies from the position \(\vec{x}\) till the border of the fireball. Finally, in (3) we integrate over all initial resonance positions \(\vec{x}\) with the phase space distribution (2).
In the case when the partial width of decay channel $j$ does not change in medium
$\Gamma_j^{(r)*} = \Gamma_j^{(r)0}$, decay products are not rescattered $P_{j\lambda}^{(r)} = P_{\text{rec}} = 1$ and the total width
$\Gamma_{\text{tot}}^{(r)*} \neq \Gamma_{\text{tot}}^{(r)0}$, we have
\begin{equation}
\eta_j^{(r)}(p) = \langle D(\tau) + \Gamma_{\text{tot}}^{(r)0} \int_0^\tau \text{d}t D(t) \rangle.
\end{equation}
This expression corresponds, e.g., to the case when resonances are reconstructed in the
leptonic channels. Note that for $\Gamma_{\text{tot}}^{(r)*} = \Gamma_{\text{tot}}^{(r)0}$ we have $\eta_j^{(r)} \equiv \eta_j^{(r)}$, for $\Gamma_{\text{tot}}^{(r)*} > \Gamma_{\text{tot}}^{(r)0}$ we
have $\eta_j^{(r)} < \eta_j^{(r)}$ and if $\Gamma_{\text{tot}}^{(r)*} < \Gamma_{\text{tot}}^{(r)0}$ then $\eta_j^{(r)} > \eta_j^{(r)}$.

After the general considerations we specify the model of the fireball expansion,
which is used in our numerical calculations. We assume a homogeneous spherical
fireball with the constant density and temperature profiles. The primordial resonance
momentum distribution
\begin{equation}
f_r(\vec{x}, \vec{p}) = \exp \left[ -\frac{E_r - \vec{p} \cdot \vec{u}(\vec{x})}{T_0 \sqrt{1 - \vec{u}^2(\vec{x})}} \right],
\end{equation}
is determined by the temperature $T_0$, flow velocity profile $\vec{u}(\vec{x}) = v_f \vec{x}/R_0$ and radius
$R_0$. The fireball expands $R(t) = R_0 + v_f t$, its density evolves as $\rho(t) = \rho_0 R_0^3/R^3(t)$ and
the temperature decreases as $T(t) = T_0 R_0/R(t)$ as expected for relativistic pion gas,
cf. [15]. Time of flight of a resonance inside a fireball starting from a position $\vec{x}$ till the
border is given by
\begin{equation}
\tau_r(\vec{v}, \vec{x}) = \left( \sqrt{(\vec{v} \cdot \vec{x} - v_f R_0)^2 + (R_0^2 - \vec{x}^2)} \right) \left( \vec{v}^2 - v_f^2 \right)^{-1},
\end{equation}
which is valid for $|\vec{x}| < R_0$ and $|\vec{v}| > v_f$. In the case $|\vec{v}| < v_f$ we put $\tau_r = \infty$. Parameters
$R_0$, $T_0$, $v_f$, serve as input for numerical evaluations below.

The particular realization of (3) is a rather crude approximation. However, the final
results are found [14] to be rather insensitive to the details of hydrodynamical evolution
of a fireball, being determined mainly by the values of $\Gamma_{\text{tot}}^{(r)*} R_0$, $\Gamma_{\text{tot}}^{(r)*} \tau_{\text{f.o.}}$, and $v_f$.

4. Applications

First we discuss numerical results obtained in [14] for $\phi$ meson yields reconstructed via
$K^+K^-$ and $\mu^+\mu^-$ channels in central Pb+Pb collisions at 158 GeV/n SPS energy. Being
dominantly an $s\bar{s}$ state, the $\phi$ mesons can decouple quite early, since its interaction with
non-strange matter is suppressed according to OZI rule. The mean free path $\lambda_\phi$ of $\phi$
mesons in hadron gas is estimated in [19]. Comparison with mean free paths of pions
and kaons, $\lambda_\pi, K$, from [20] gives $\lambda_\pi \lesssim \lambda_K < \lambda_\phi$ for temperatures $T_{\text{therm}} < T < T_{\text{chem}}$.
Therefore condition (1) can be satisfied.

For a comparison with experimental data we define the following suppression factors
\begin{equation}
\mathcal{R}(m_T) = \mathcal{R}_K(m_T)/\mathcal{R}_\mu(m_T), \quad \mathcal{R}_{K,\mu}(m_T) = \langle \eta_{K,\mu}^{(\phi)}(p) \rangle_y / \langle \eta_0^{(\phi)}(p) \rangle_y,
\end{equation}
where $< \ldots >_y$ means the integration over experimental rapidity interval. The apparent distribution of $\phi$ mesons in the hadronic channel $(K\bar{K})$, $\eta_{K}^{(\phi)}$, is calculated according to (3). In the leptonic channel, $\eta_{\mu}^{(\phi)}$ we use (5).

First, we evaluate suppression factor (8) without any modification of $\phi$ properties in medium. In this case we have $R_{\mu}(m_T) \equiv 1$ and $R(m_T) = R_K(m_T)$. We use several combinations of input parameters ($T_0, R_0, v_f$) chosen consistently with the $\phi$-meson freeze-out temperature $T_0$ which we vary between $T_{\text{chem}}$ and $T_{\text{therm}}$: (i) (150 MeV, 20 fm, 0.5) , (ii) (160 MeV, 15 fm, 0.46) , (iii) (170 MeV, 10 fm, 0.41). Size of the fireball $R_0$ at the moment of $\phi$ freeze-out has to be comparable with $\phi$ meson mean free path $\lambda_{\phi}$. The above values for different temperatures are taken according to estimations of $\lambda_{\phi}$ in [19]. Flow velocities are adjusted to reproduce the slope of $\phi$ meson $m_T$ distribution measured by the NA50 collaboration: $T_{\text{eff}} = 218$ MeV. The fireball life time is determined by equation $T(\tau_{f.o.}) = T_{\text{therm}}$

To reproduce results of RQMD calculations described in Ref. [8] we take freeze-out temperature $T_{\text{therm}} = 80$ MeV, the kaon mean free path $\lambda_K(t) = \lambda_K^0 R_0^3/R^3(t)$ with $\lambda_K^0 = 0.5$ fm and $P_{\text{rec}} = 1$. The temperature corresponds to the lowest limit allowed by the analysis [13]. The results are shown in Fig. 1 (left panel) by solid lines. The limiting scenario considered in [8], when the freeze-out volume is determined by the last kaon interactions, can be reproduced with $T_{\text{therm}} = 40$ MeV. This case is shown by dash lines. The solid lines in the left panel of Fig. 1 we take as a reference point for our further investigation of in-medium effects.

Let us now consider the case when the $\phi$ meson width increases strongly in hadronic medium. We simulate this effect by decreasing the kaon mass, which can result e.g.
from rescattering of kaons on pions through $K\bar{K}$ and heavier kaonic resonances [21]. The modification of kaon properties in medium prevent the \( \phi \) meson reconstruction even when kaons can leave a fireball without a hard rescattering. Leaving the fireball, kaons have to come back to their vacuum mass shell. Due to the energy conservation the momenta of kaons change and, thereby, the invariant mass and momentum of the pair. For this effect we account by putting \( P_{\text{rec}} = 0 \). Then the both suppression factors \( R_{\phi} \) and \( \mathcal{R}_m \) depend only on the total \( \phi \) meson width. The \( \phi \) total width reads as \( \Gamma_{\phi}^{(r)}(\delta m_K) = \Gamma_{KK}^2 p_{KK}^3 (m_K + \delta m_K)/p_{KK}^3 (m_K) + \Gamma_{\rho\pi} \) with \( p_{KK}(m_K) = \frac{1}{2} m_\phi (1 - 4 m_K^2/m_\phi^2)^{1/2} \). The vacuum widths of \( \phi \to K\bar{K} \) and \( \phi \to \rho\pi \) decay processes are equal to \( \Gamma_{KK} = 3.68 \text{ MeV} \) and \( \Gamma_{\rho\pi} = 0.76 \text{ MeV} \). We do not consider here in-medium change of the \( \Gamma_{\rho\pi} \) width, which effects weakly the resulting suppression factor [14]. We restrict ourselves to rather conservative modification of kaon masses. Initially, at the \( \phi \) freeze-out moment we put \( \delta m_K^0 = -30 \text{ MeV} \), and then it decreases linearly with the decreasing fireball density \( \delta m_K(t) = \delta m_K^0 R_{\mu}^3/R(t)^3 \). It corresponds to the initial \( \phi \) width \( \Gamma_{\phi}^{(r)} \simeq 20 \text{ MeV} \). In this case \( R_{\mu} < 1 \) and at small \( m_T - m_\phi \) region \( R_{\mu} \) can be suppressed up to 40–60\%. Thus, for a given freeze-out temperature \( T_0 \) we have to readjust the flow velocity \( v_f^0 \) to reproduce the slope of the \( m_T \) distribution measured in dimuon channel by NA50 [2]. For our three sets of parameters specified above we obtain new flow velocities: (i) \( v_f^0 = 0.38 \), (ii) \( v_f^0 = 0.35 \), (iii) \( v_f^0 = 0.28 \).

The results for a relative suppression of hadronic and leptonic channels are presented in the right plane of Fig. 1. Thick solid, dashed and dotted lines drawn for cases (i)-(iii) should be compared with the solid lines in the left plane. We observe that the increase of the \( \phi \) width results in the overall increase of the suppression effect by about 20\%. The suppression factors for leptonic and hadronic channels, separately, are shown in Fig. 1 as well. The increase of the \( \phi \)-meson width provides a strong suppression of \( \mathcal{R}_K(m_T \to m_\phi) \sim 0.15 \). However, since the dimuon channel is also suppressed the resulting ratio \( \mathcal{R} \) remains on the level \( \sim 0.3 \) for small \( m_T - m_\phi \).

Let us now consider closer dependence of the suppression factor on the fireball parameters \( \tau_{f.o.} \) and \( R_0 \). First, we simplify the time dependence of the total width. We use a linear in density interpolation between the initial value at the freeze-out moment, \( \Gamma_{\text{in}}^{(r)} \) and the vacuum value

\[
\Gamma_{\text{tot}}^{(r)}(t) = \Gamma_{\text{tot}}^{(r)0} + (\Gamma_{\text{in}}^{(r)} - \Gamma_{\text{tot}}^{(r)0}) \left( R_0/R(t) \right)^3.
\]

This approximation works still well and can reproduce the right panel of Fig. 1, using \( \Gamma_{\text{in}} = 20 \text{ MeV} \) within 5–10\% accuracy. We will vary parameters \( R_0 \) and \( \tau_{f.o.} \) keeping other parameter fixed: \( T_0 = 150 \text{ MeV} \), \( v_f = 0.5 \), and \( P_{\text{rec}} = 0 \). In Fig. 2 we present the contour plot of the value \( \mathcal{R}_K(m_T = m_\phi) \) as a function the dimensionless variables \( \Gamma_{\text{in}}^{(r)} \) and \( \Gamma_{\text{in}}^{(r)} \), calculated for \( \Gamma_{\text{in}}^{(r)} = 10, 20, 30 \text{ MeV} \). The thin solid line shows the level \( \mathcal{R}_K(m_T = m_\phi) = 0.5 \) for the vacuum width \( \Gamma_{\text{in}}^{(r)} = \Gamma_{\text{tot}}^{(r)0} = 4.43 \text{ MeV} \). We see that for the vacuum width the 50\% suppression can be reached only for rather large \( \tau_{f.o.} \sim 40 \text{ fm} \). From this plot we can also read out the minimal combinations of parameters \( (R_0, \tau_{f.o.}) \) required to attain a certain degree of suppression. For instance, \( \mathcal{R}_K(m_\phi) < 0.2 \) will be
reached (we pick out the points closest to the origin on the lines labeled with 0.2) for 
\( \Gamma_{\text{in}}^{(\phi)} = 10 \text{ MeV} \) if \( (\tau_{\text{f.o.}} > 67 \text{ fm}, R_0 > 15 \text{ fm}) \), for \( \Gamma_{\text{in}}^{(\phi)} = 20 \text{ MeV} \) if \( (\tau_{\text{f.o.}} > 44 \text{ fm}, R_0 > 15 \text{ fm}) \), and for \( \Gamma_{\text{in}}^{(\phi)} = 30 \text{ MeV} \) if \( (\tau_{\text{f.o.}} > 33 \text{ fm}, R_0 > 12 \text{ fm}) \). Have we fixed the size of a fireball to be about 20 fm, the level \( R_K(m_\phi) = 0.2 \) can be arrived at \( \tau_{\text{f.o.}} = 63, 39, 26 \text{ fm} \) for \( \Gamma_{\text{in}}^{(\phi)} = 10, 20 \) and 30 MeV, respectively.

We turn now to the \( \Lambda^*(1520) \) and \( \overline{K}^*(892) \) resonances. Their mean free paths in the hot hadronic matter have not been studied so far, unfortunately. There is also no additional mechanism like OZI for \( \phi \) mesons which would suppress the \( \Lambda^* \) and \( \overline{K}^* \) interaction with surrounding pions, kaons, and nucleons. Moreover, \( \pi \Lambda^* \) scattering has contributions from s-channel hyperon exchange processes, particularly the reaction \( \pi \Lambda^* \rightarrow \Sigma^*(1385) \rightarrow \pi \Lambda^* \) should be operative due to the s-wave \( \pi \Lambda^* \Sigma^* \) coupling. Therefore we can expect that the mean free paths of \( \Lambda^* \) and \( \overline{K}^* \) are comparable with those of pions and kaons. Hence their final momentum distribution should be formed rather close to the common break-up of the fireball.

In Fig. 2 we depict the contour plots of the quantity
\[
R^{(r)}(m_T) = \frac{\eta^{(r)}_{\text{hadr.}}(p) > y}{\eta^{(r)}_0(p) > y}
\]
evaluated for \( m_T = m_r, T = 150 \text{ MeV}, v_f = 0.5 \). The apparent distribution in the dominant hadronic channel \( \eta^{(r)}_{\text{hadr.}} \) is calculated according to (3) with \( P_{\text{rec}} = 0 \) and depends only on the total width of the resonance. The time dependence of the width is given by (9) with \( \Gamma^{(r)}_{\text{in}} \) varying in the broad range separately for each resonance. The last panel in Fig. 2 shows us that to have for \( \overline{K}^* \) mesons the suppression factor \( R^{(K^*)}(m_{K^*}) > 0.5 \), we should have \( \Gamma^{(K^*)}_{\text{in}} \tau_{\text{in}} \sim 0.6–1 \). This translates for \( \Gamma^{(K^*)}_{\text{in}} \sim 50–80 \text{ MeV} \) into \( \tau_{\text{f.o.}} \sim 2–2.4 \text{ fm} \). Hence the \( \overline{K}^* \) mesons should indeed be produced close to the fireball break up. Using these values for \( \Lambda^* \) we find from the middle plane in Fig. 2
that the ratio $\mathcal{R}(\Lambda^*)(m_{\Lambda^*})$ becomes less than 0.5 only if $\Gamma_{\text{in}}(\Lambda^*) \gtrsim 120$ MeV. This is a very large value. Although there are indications that $\Lambda^*(1520)$ properties suffer a strong modifications in nuclear medium acquiring the total width of the order 100 MeV at the normal nuclear matter density [17], calculations have been done so far for cold nuclear matter only. At high temperatures these effects might be reduced. Alternatively we can suggest that $\Lambda^*(1520)$ hyperons decouple from the fireball at some earlier stage than $K^*$ mesons. Then we obtain the following estimates for the time between $\Lambda^*$ freeze-out and the fireball breakup: $\tau_{\text{f.o.}} \sim 6$ fm for $\Gamma_{\text{in}}(\Lambda^*) \sim 30$ MeV and $\tau_{\text{f.o.}} \sim 9$ fm for the vacuum width.

Finally we do not exclude a possibility that the formation of $J = \frac{3}{2}(-)$ baryonic state $\Lambda^*(1520)$ in heavy-ion collisions is already primarily suppressed. The purpose of the presented work is to find out to what extent the DPR suppression mechanisms enhanced by the in-medium modification of resonance width is able to accommodate experimental data.

5. Summary

We investigate dependence of the decay-product rescattering mechanism of the resonance production suppression on the size of the hadronic fireball and on the time between resonance freeze-out and fireball break-up. Possible modification of the resonance width in medium is shown to enhance the suppression. The model is applied to the production of $\phi(1020)$, $\Lambda^*(1520)$ and $K^*(892)$ particles at SPS energies. We conclude that in the case of $\phi(1020)$ mesons the discrepancy between $\phi$ momentum distributions observed in $K^+K^-$ (NA49) and leptonic (NA50) channels can be explained if at the moment of the $\phi$ freeze-out the $\phi$ total decay width is about 30 MeV and after freeze-out the fireball lives about 20 fm/c till the break-up. The observed (NA49) signals of $K^*(892)$ meson production indicate that $K^*$ mesons escape from the fireball at the moment very close to the breakup (not further than 2.0-2.4 fm/c). Otherwise their apparent distribution would be strongly suppressed. We can obtain the attenuation of the $\Lambda^*(1520)$ on the level of 50% assuming either a very large width of the resonance $\gtrsim 120$ MeV at the freeze-out moment close to fireball break-up or that $\Lambda^*$ particles leave the fireball at least 6–9 fm/c before breakup.

We conclude that the resonance production in heavy ion collisions can serve as an indicator of the fireball dynamics at the last stage of heavy-ion collision. To draw precise quantitative conclusions careful investigation of the modification of resonance properties in hadronic medium is necessary.

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Resonances from a Hadronic Fireball

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