Phi **meson propagation in a hot hadronic gas**

L. Alvarez-Ruso and V. Koch (GSI-Darmstadt and LBNL-Berkeley)

The Φ is a nice probe for the properties of the matter created in ultra-relativistic heavy ion collisions, since it is not masked behind other resonances in the mass spectra. It decays,among several other possibilities, into kaon pairs (K^+K^-), and more rarely into dileptons (e^+e^-, $\mu^+\mu^-$); both channels have been detected at CERN-SPS [1, 2]. Dileptons have negligible final state interactions with the hadronic environment, so they sense the entire evolution of the system. On the contrary, detectable kaons from Φ decay probably emerge only at freeze out.

It is widely believed that the Φ mean free path in a hot hadronic fireball is large due to the small cross section for scattering with non strange hadrons. This implies that Φ spectra would retain the information about the stage of the collision at which the plasma hadronizes [3]. Available calculations [4, 5, 6] seem to support this idea. However, Φ production in $Pb-Pb$ collisions at SPS shows some intriguing features that are difficult to match with the picture of a Φ weakly interacting with the hadronic medium. Both absolute yields and inverse slope parameters in the transverse mass (m_t) distributions exhibit different values when measured via $\mu^+\mu^-$ or K^+K^- decays [7]. The inverse slope, as obtained from the hadronic measurement, suggests that the Φ's flow together with pions, kaons and protons, while the dilepton measurement is consistent with the assumption of an early freeze out. It has also been observed that the rapidity distribution (extracted from kaon pairs) in $Pb-Pb$ is about 50 % broader than in pp [1]. The modification of visible Φ spectra due to kaon re-scattering inside the fireball is an obvious and important correction but does not fully explain the discrepancies [8].

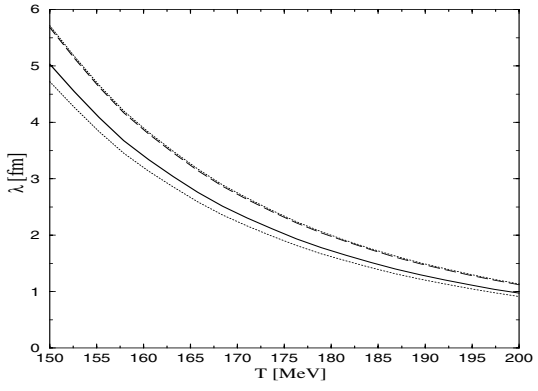

Figure 1: Mean free path of Φ meson as a function of temperature (solid line). The dotted lines constrain the region of possible values when the model parameters are changed as described in the text. The dashed line is the contribution from Φ-number changing processes alone.

Here we calculate Φ collision rates and mean free path in a hot hadronic gas of pseudo-scalar (π, K) and vector mesons (ρ, ω, K^*, Φ). The reaction cross sections are obtained within the Hidden Local Symmetry Lagrangian (HSL) [9], which includes both Goldstone boson and vector mesons in a manner consistent with the symmetries of QCD. The use of such a realistic model allows us to take into account many mechanisms that are not present in calculations that rely only in couplings extracted from observed decays but are allowed by the symmetries. This is, for instance, the case of vertices like ΦK^*K, ρK^*K^* and many others. As a consequence, we shall see that at temperatures between 150 and 200 MeV the Φ mean free path in hadronic matter is considerably smaller than what has been estimated so far (see Fig. 1). Finally, using a simple model for the expansion dynamics we find a moderate (20 %) reduction of the Phi-yield due to this rescattering (Fig. 2). Our findings thus cannot explain the difference between the observed Phi-mesons in the leptonic and hadronic channel at the CERN-SPS.

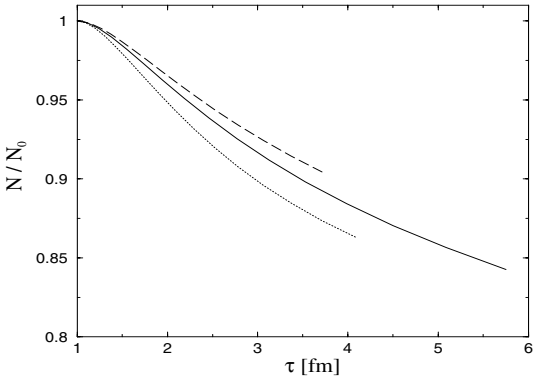

Figure 2: Time dependence of the ratio N/N_0 at zero (solid line) and nonzero (dashed line) chemical potentials, as described in the text. The dotted line stands for the case of $\mu_{K^*} = 0$ while keeping $\mu_{\pi,K,\rho,\omega} \neq 0$.

References

[1] S. V. Afanasiev et al. (NA49), Phys. Lett. **B491**, 59 (2000).

[2] M. C. Abreu et al. (NA50), J. Phys. **G27**, 405 (2001).

[3] A. Shor, Phys. Rev. Lett. **54**, 1122 (1985).

[4] C. M. Ko and D. Seibert, Phys. Rev. **C49**, 2198 (1994), `nucl-th/9312010`.

[5] K. Haglin, Nucl. Phys. **A584**, 719 (1995), `nucl-th/9410028`.

[6] W. Smith and K. L. Haglin, Phys. Rev. **C57**, 1449 (1998), `nucl-th/9710026`.

[7] D. Rohrich, J. Phys. **G27**, 355 (2001).

[8] S. C. Johnson, B. V. Jacak, and A. Drees, Eur. Phys. J. **C18**, 645 (2001), `nucl-th/9909075`.

[9] M. Bando, T. Kugo, and K. Yamawaki, Phys. Rept. **164**, 217 (1988).