Studying the ω properties in pA collisions via the $\omega\to\pi^0\gamma$ decay

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The modification of the ω-meson properties in nuclear matter has become a challenging subject in dilepton physics from $\pi^- A$, pA and AA collisions. Here the dilepton (e^+e^-) radiation from ω's propagating in finite density nuclear matter is directly proportional to the ω spectral function which becomes distorted in the medium due to the interactions with nucleons. ω-production in pA collisions can be considered as a means to study the ω-properties at normal nuclear density under rather well controlled conditions.

The in-medium ω-spectral function can also be measured directly by the decay $\omega\to\pi^0\gamma$. The advantage of the $\omega\to\pi^0\gamma$ mode is due to an isolation of the ω-signal, while the dileptonic mode always has to fight with a background from ρ^0 decays which are as well produced in pA collisions with compatible probability. The calculations (see [1] for details and references) are performed within the transport model used before for ρ^0 and $K^\pm$ studies [2] by taking into account both the direct $pN\to\omega pN$, $pN\to\omega pN\pi$ and secondary $pN\to\pi NN$, $\pi N\to\omega N$ production mechanisms as well as ωN elastic and inelastic interactions in the target nucleus and accounting for $\pi^0 N$ rescattering. Here the ω propagation is described by the Hamilton's equation of motion and its decay to $\pi^0\gamma$ by Monte Carlo according to the survival probability $P_\omega(t-t_0)=\exp(-\Gamma_V(t-t_0))$ in the rest frame of the meson created at time t_0, while Γ_V=8.4 MeV denotes the inverse ω-life time in the vacuum.

To examine the feasibility of a direct detection of in-medium modifications via the $\pi^0\gamma$ invariant mass spectrum, calculations for p+Cu collisions at 2.4 GeV are performed by introducing a real and imaginary part of the ω-potential

$$U_\omega = \frac{\Re\Sigma_\omega}{2M_0} \simeq M_0\,\beta\frac{\rho}{\rho_0} \qquad (1)$$

and width

$$\Gamma^* = \frac{\Im\Sigma_\omega}{2M_0} \simeq \Gamma_0+\Gamma_{coll}\frac{\rho}{\rho_0} \qquad (2)$$

in the $t-\rho$-approximation. Here M_0 and Γ_0 are the bare mass and width of the ω-meson in vacuum while ρ is the local baryon density and ρ_0=0.16 fm^{-3}. The parameter $\beta\simeq-0.16$ was adopted from various models cited in [1]. The predictions for the ω-meson collisional width Γ_{coll} at density ρ_0 range from 20 to 50 MeV.

These estimates are based on the local density approximation and neglect a momentum dependence of the ω-potential. Since the model uncertainties are quite substantial [3, 4, 5] this situation needs experimental clarification.

The solid histograms in Fig. 1 show the $\pi^0\gamma$ invariant mass spectra from p+Cu collisions at 2.4 GeV calculated with Γ_{coll}=20 MeV (upper part) and Γ_{coll}=50 MeV (lower part) while employing the potential (1). The results (including an 'experimental' resolution of 10 MeV) indicate a substantial enhancement of the low mass $\pi^0\gamma$ spectra due to the contribution from ω-mesons decaying inside the nucleus while feeling the attractive potential (1).

These experiments might be carried out at COSY with a dedicated photon detector looking for the 3γ invariant mass distribution and gating on events where 2 γ's yield the invariant mass of a π^0. This program is complementary to dilepton studies in these reactions, that will be carried out with HADES detector at GSI Darmstadt [6].

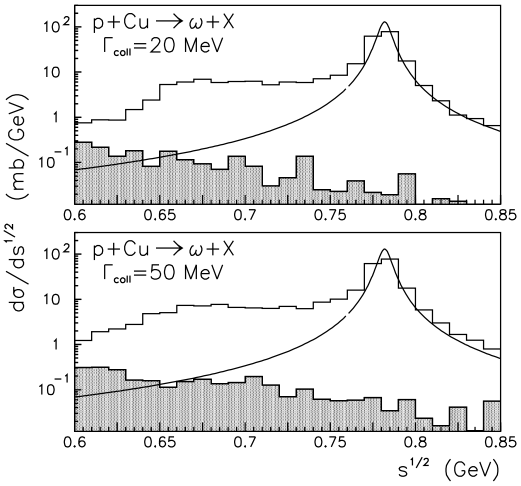

Figure 1: The $\pi^0\gamma$ invariant mass spectra from p+Cu collisions at 2.4 GeV calculated for Γ_{coll}=20 and 50 MeV (open histograms). The hatched histograms indicate the contributions from ω-mesons, that decay at finite density and include π^0 rescattering, while the solid curves show the ω-spectral function in vacuum for comparison.

References

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