OPEN-CHARM ENHANCEMENT AT FAIR?

L. Tolós
J. Schaffner-Bielich and H. Stöcker
GSI & Institut für Theoretische Physik & FIAS (Univ. Frankfurt).

SQM06

1. Motivation
2. Coupled-channel approach:
   \( \Lambda_c(2593) \) resonance
3. The D-meson
   in hot and dense matter
4. Conclusions & Future
Motivation

• $\Psi'$ and $J/\Psi$ suppression

• D-mesic nuclei

• Open-charm enhancement

$$\mathbf{K} = \begin{pmatrix} \bar{K}^0 \cr -K^- \end{pmatrix} \begin{pmatrix} \bar{d} \\ \bar{u} \end{pmatrix}_{s=-1} \quad \mathbf{D} = \begin{pmatrix} D^+ \\ D^0 \end{pmatrix} \begin{pmatrix} \bar{d} \\ \bar{u} \end{pmatrix}_{c=1}$$

$I(J^P) = 1/2 \ (0^-)$

Predictions for the D-meson potential
(QSR, QMC, chiral model): -50 to -140 MeV at $\rho = \rho_0$
Coupled-channel approach: $\Lambda_c(2593)$ resonance

The $s$-wave $DN$ amplitude obtained via *Lippman-Schwinger equation*

$$T_{if}(k_i, k_f; \sqrt{s}) = V_{if}(k_i, k_f) + \sum_l \int \frac{d^3k_l}{(2\pi)^3} \frac{V_{il}(k_i, k_l) T_{lf}(k_l, k_f; \sqrt{s})}{\sqrt{s} - E_l(k_l) - \omega_l(k_l) + i\epsilon}$$

in *coupled channels* ($\pi\Lambda_c$, $\pi\Sigma_c$, $DN$, $\eta\Lambda_c$ and $\eta\Sigma_c$)

using a separable potential as bare interaction

$$V_{i,j}(k, k') = g^2 \frac{C_{i,j}}{\Lambda^2} \Theta(\Lambda - k) \Theta(\Lambda - k')$$

$g$ (coupling constant), $\Lambda$ (cutoff), $C_{i,j}$ (SU(3) matrix with u,d,c)
\( \Lambda(2593)_c \) resonance

\[ I = 0, \quad J^P = (1/2)^- \quad \text{with} \quad \Gamma = 3.6^{+2.0}_{-1.3} \text{ MeV} \]

\[
\frac{d\sigma}{dm_{\pi\Sigma_c}} \propto |T^{I=0}_{\pi\Sigma_c \rightarrow \pi\Sigma_c}|^2 \rho_{cm}
\]
The D-meson in hot and dense matter

*Brueckner-Hartree-Fock approach* for the in-medium $DN$ interaction

\[
G = V + V \frac{Q}{\omega - H} V + V \frac{Q}{\omega - H} V \frac{Q}{\omega - H} V + \ldots
\]

*Bethe–Goldstone equation*

- $Q$ Pauli blocking
- $H$ Particle dressing
\[ U_D(k, E_D^{qp}) = \sum_{N \leq F} \langle DN \mid G_{DN \rightarrow DN}(\Omega = E_N^{qp} + E_D^{qp}) \mid DN \rangle \]

Self-consistently!!

After self-consistency for the on-shell \( U_D(k, E_D^{qp}) \),

the D-meson self-energy is

\[ \Pi_D(k_D, \omega) = 2 \sqrt{k_D^2 + m_D^2} U_D(k_D, \omega) , \]

the D-meson single-particle propagator is

\[ D_D(k_D, \omega) = \frac{1}{\omega^2 - k_D^2 - m_D^2 - \Pi_D(k_D, \omega)} , \]

and the D-meson spectral density is

\[ S_D(k_D, \omega) = -\frac{1}{\pi} \text{Im} \, D_D(k_D, \omega) . \]
Finite temperature effects:

G-matrix at finite temperature obtained by replacing

\[ Q_{MB} \rightarrow Q_{MB}(T) \]
\[ E_M, E_B \rightarrow E_M(T), E_B(T) \]
\[ G(\Omega) \rightarrow G(\Omega, T) \]

Then, the D-meson optical potential

\[ U_D(k, E_{Dp}) = \sum_{N \leq F} \langle DN \mid G_{DN \rightarrow DN}(\Omega = E_N + E_{Dp}) \mid DN \rangle \]
\[ \downarrow \text{T effects} \]

\[ U_D(k, E_{Dp}, T) = \int n(k, T) \, d^3k \, \langle DN \mid G_{DN \rightarrow DN}(\Omega, T) \mid DN \rangle \]
The D-meson spectral density for $T=120$ MeV
Open-charm enhancement?
$D^+ n (D^0 p)$ transition rates for $T=120$ MeV
Conclusions & Future

OBJECTIVE: The D-meson spectral density in hot nuclear matter to address open-charm enhancement

METHOD: To solve the $DN$ coupled-channel Bethe-Goldstone equation self-consistently at finite temperature taking as bare $DN$ interaction a separable potential

- $\Lambda_c(2593)$ resonance generated dynamically for $(g^2,\Lambda)$
- The quasiparticle peak stays close to its free position (self-consistent coupled-channel effects result in a overall reduction of the in-medium modifications)

BUT the D-meson develops a considerable width
CONCLUSION: The medium modifications to the D-mesons in A+A collisions will be dominantly on the width and not on the mass.

Open-charm enhancement??

FUTURE:

• Improve bare interaction by extension to SU(4) for u-,d-,s- and c-quark content. Some recent work by Hofman, Lutz and Korpa.

• CBM experiment at FAIR (GSI)

More details:
