Novel effects in J/Psi production in nuclei

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IS

Diffraction 2010, Otranto
### Introduction

<table>
<thead>
<tr>
<th>Nuclear suppression of J/Ψ</th>
<th>considered sensitive probe of produced medium in heavy ion collisions</th>
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<tbody>
<tr>
<td>Difficulty</td>
<td>distinguish between</td>
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<td>ISI (cold nuclear matter effects)</td>
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<td>FSI (dense matter effects)</td>
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<td>Comments</td>
<td>ISI should be studied in pA (no dense matter effects), and extrapolate to pA (not easy)</td>
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<td>broadening has ISI only, and it is very different in pA and AA</td>
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AA collisions: several effects
- shadowing
- break-up
- double color filtering
- boosting of saturation scale

New effects:
1) Double color filtering
   Survival probability of dipole is higher than just the product
2) Boosting of saturation scale
   Multiple interactions in both nuclei stronger at high energies:
   medium more opaque than in pA

Usual simplification:
- instantaneous production
- but production time is long
pA collisions

Coherence effects in propagation of color octet

Survival amplitude

\[ S_{pA}(b, z) = \int d^2r_T W_{\bar{c}c}(r_T) \]
\[ \times \exp \left[ -\frac{1}{2} C(E_{\bar{c}c}) r_T^2 \left( \frac{7}{16} T_-(b, z) + T_+(b, z) \right) \right] \]

dipole-nucleon CS

Suppression factor

\[ R_{pA} = \frac{1}{A} \int d^2b T_A(b) \left[ 1 + \frac{1}{2} C(E_{\bar{c}c}) \langle r_T^2 \rangle T_A(b) \right]^{-1} \]
\[ \times \left[ 1 + \frac{7}{32} C(E_{\bar{c}c}) \langle r_T^2 \rangle T_A(b) \right]^{-1}. \]
1) Double color filtering

Simple example: \( cc(\bar{c}b) \) propagating through slice of nuclear matter

\[
R_{AA}(b, \bar{b}) = R_{pA}(\bar{\tau}) \times R_{pA}(b - \bar{\tau})
\]

\[
P_A(r_T, T_A) = \exp\left(-C r_T^2 T_A\right)
\]

\[
P_A(T_A) = \int d^2 r_T W(r_T) P_A(r_T, T_A) = \frac{1}{1 + C \langle r_T^2 \rangle T_A}
\]

\[
P_{AB}^{Gl}(T_A, T_B) = \frac{1}{(1 + C \langle r_T^2 \rangle T_A)(1 + C \langle r_T^2 \rangle T_B)}
\]

Correct

\[
P_{AB}(r_T, T_A, T_B) = P_A(r_T, T_A) P_B(r_T, T_B)
\]

\[
= e^{-C r_T^2 (T_A + T_B)}.
\]

\[
P_{AB}(T_A, T_B) = \frac{1}{1 + C \langle r_T^2 \rangle (T_A + T_B)},
\]
Realistic calculation:

\[ R_{AB}(b) = \frac{1}{T_{AB}(b)} \int d^2\tau \int_{-\infty}^{\infty} dz_1 \rho_A(\bar{\tau}, z_1) \int_{-\infty}^{\infty} dz_2 \rho_B(\bar{b} - \bar{\tau}, z_2) \left| \int d^2r_T W_{cc}(r_T) S_{pA}(\bar{\tau}, z_1, r_T) S_{pB}(\bar{b} - \bar{\tau}, z_2, r_T) \right|^2 \]
2) Boosting of saturation scale

In nuclei: transverse momentum distribution modified up to

\[ Q_{sA}^2 = \Delta p_T^2(E) = 2 \frac{d\sigma(r, E)}{dr^2} \Big|_{r=0} \int dz \rho_A(b, z). \]

modification of beam PDFs

\[ Q^2 \Rightarrow Q_{\text{eff}}^2 = Q^2 + Q_{sA}^2, \]

remember DGLAP

AA both colliding nuclei participate

\[ Q_{sA(B)}^2 \Rightarrow \tilde{Q}_{sA(B)}^2. \]

\[
\begin{align*}
\tilde{Q}_{sB}^2(x_B) &= \frac{3\pi^2}{2} \alpha_s(\tilde{Q}_{sA}^2 + Q_0^2) x_A g_N(x_A, \tilde{Q}_{sA}^2 + Q_0^2) T_B; \\
\tilde{Q}_{sA}^2(x_A) &= \frac{3\pi^2}{2} \alpha_s(\tilde{Q}_{sB}^2 + Q_0^2) x_B g_N(x_B, \tilde{Q}_{sB}^2 + Q_0^2) T_A.
\end{align*}
\]
Results

Effect on break up CS

Effect on suppression factor