Diffractive double quarkonium production at the LHC

Rafael Palota da Silva, UFPel, Brazil
In collaboration with V. P. Gonçalves and C. Brenner Mariotto

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Hadron diffraction

- A reaction with no quantum numbers exchange between the interacting particles is, at high energies, a diffractive reaction.
- A diffractive reaction is characterized by a large, non-exponentially suppressed, rapidity gap at the final state.
Singlle Diffraction (SD) x Double Diffraction (DD)
Cross section calculation

- Cross section factorization

\[ d\sigma(pp \rightarrow p + H_1 H_2 + p) = \sum_{n} g_p^D(x_1, \mu^2) g_p^D(x_2, \mu^2) \]
\[ \times d\hat{\sigma}[gg \rightarrow Q \bar{Q}_n + Q \bar{Q}_n] \cdot \langle \mathcal{O}_{n}^{H_1} \rangle \langle \mathcal{O}_{n}^{H_1} \rangle \]

- Diffractive gluon distribution

\[ g_p^D(x, Q^2) = \int dx_P d\beta \delta(x - x_P) f_P^p(x_P) g_P(\beta, Q^2) \]
\[ = \int_1^{1} \frac{dx_P}{x_P} f_P^p(x_P) g_P\left(\frac{x}{x_P}, Q^2\right) \]

- Pomeron flux

\[ f_P^p(x_P) = \int_{t_{\min}}^{t_{\max}} dt f_P/_{P}(x_P, t) = \int_{t_{\min}}^{t_{\max}} dt \frac{A_P e^{B_P t}}{2\alpha_P(t-1)} \]
NRQCD - quarkonium production

The non relativistic QCD (NRQCD) takes into account the Color Singlet Model (CSM) and the Color Octet Model (COM).

\[
H_2 \; H_1 = + + + + \cdots
\]
Results for Single Diffraction

$pp \rightarrow 2J/\Psi$

$\sqrt{s} = 13\; TeV$

$|y| < 8$

$pp \rightarrow 2\Upsilon$

$\sqrt{s} = 13\; TeV$

$2 < |y| < 4.5$
Results for Double Diffraction

\[ pp \rightarrow 2J/\Psi, \quad \sqrt{s} = 13 \text{ TeV}, \quad |y| < 8 \]

\[ pp \rightarrow 2\Upsilon, \quad \sqrt{s} = 13 \text{ TeV}, \quad 2 < |y| < 4.5 \]
Rapidity distribution and ratios

\[ \frac{d\sigma}{dy} (\text{nb}) \]

\( \sqrt{s} = 13 \text{ TeV} \)

- CSM + COM single diffractive
- CSM + COM double diffractive
- CSM + COM inclusive

\( pp \rightarrow 2J/\Psi \)

\[ R \left[ \frac{d\sigma(J/\Psi)}{d\sigma(\Upsilon)} \right] \]

\( \sqrt{s} = 13 \text{ TeV} \)

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Double diffractive
Single diffractive

\( |y| \leq 8 \)
The cross sections are dominated by CSM, with the COM being important at large $p_T$, where the magnitude of the cross sections is strongly reduced.

The contribution of diffractive production is non-negligible at Run II LHC energy, which implies that a future experimental analysis is, in principle, feasible.

The ratio between cross sections can be useful to probe the treatment of absorptive corrections.

Future analysis of the diffractive events can be useful to constrain the underlying assumptions present in the description of the double quarkonium production.
Thanks!