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Complete one-loop study of exclusive J/ψ and Υ photoproduction

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We perform the first complete one-loop study of exclusive photoproduction of vector quarkonia off a proton, including full generalised-parton-distribution (GPD) evolution. We confirm the perturbative instability of the cross section at high photon-proton-collision energies at Next-to-Leading Order (NLO) using collinear factorisation. Such an instability is known since 20 years and has been tackled by a scale-fixing criterion and the so-called Q_0-subtraction procedure to avoid the over-subtraction of the collinear singularities. In this work, we instead resolve this problem by matching High-Energy Factorisation (HEF) in the Doubly-Logarithmic Approximation (DLA) to collinear factorisation as previously done for inclusive quarkonium production. Such a DLA is a subset of the Leading-Logarithmic Approximation (LLA) of HEF which resums higher-order QCD corrections proportional to $\alpha_s^n \ln^{n-1}(\hat{s}/M^2)$ in the Regge limit $\hat{s} \gg M^2$. This is strictly consistent with the NLO DGLAP evolution of GPDs. We use two models for the GPDs entering the calculation: the first one is taken from the PARTONS framework, which includes a full GPD evolution. The second one corresponds to an approximation valid at high energies in terms of Parton Distributions Functions (PDFs) via the Shuvaev transform, in which only PDFs are evolved. We find that the resummation cures the instability observed for the NLO calculation in CF at high energies and finally paves the way for GPD-based NLO phenomenology for exclusive quarkonium photoproduction. We then compare our results for the two GPD models and assess the reliability of the Shuvaev transform as a means to probe the small x gluon PDFs via the exclusive photoproduction of vector quarkonia.

Primary authors: FLETT, Christopher (IJCLab); WAGNER, Jakub (National Centre for Nuclear Research); LANSBERG, Jean-Philippe (IJCLab- Paris-Saclay U. - CNRS); NEFEDOV, Maxim (IJCLab); SZNAJDER, Paweł (NCBJ); NABEEBACCUS, Saad (IJCLab)

Presenter: LANSBERG, Jean-Philippe (IJCLab- Paris-Saclay U. - CNRS)

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