Reanalysis of the EMC Charm Production Data With Extrinsic and Intrinsic Charm at NLO *

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The European Muon Collaboration (EMC) [1] established that photon-gluon fusion (PGF)in QCD, the analogue of the Bethe-Heitler reaction in QED, explains most of the charm deep inelastic structure function F_2^c. However, the EMC data was not in complete agreement with PGF at all x and Q^2. The disagreement at large x and Q^2 suggested that a higher-twist component of charm production was necessary, called intrinsic charm (IC) [2] to distinguish it from PGF, referred to as extrinsic charm (EC).

In the analysis of the EMC data [1], a relatively simple model was used for both the EC and IC components. At the time, only the LO contributions to F_2^c from both models were available. Afterwards, Hoffman and Moore [3] calculated the next-to-leading order (NLO) corrections to the IC component and discussed their effects on the EMC analysis. Based on LO photon-gluon fusion, they found evidence for an 0.3% IC component in the proton. Since the complete NLO results are now available for both EC and IC production, a more detailed QCD analysis of the EMC results is finally possible, allowing us to make a more reliable determination of the IC content of the proton.

Up to NLO, the IC component of the structure function is [3]

$$F_2^c = \frac{8}{9}\xi \left[c(\xi,\gamma) + \int_{\xi/\gamma}^1 \frac{dz}{z} c(\xi/z,\gamma)\sigma_2^{(1)}(z,\lambda) \right] . \quad (1)$$

Likewise the NLO EC structure function is

$$\begin{aligned} F_2 &= \frac{Q^2\alpha_s(\mu^2)}{4\pi^2 m_c^2}\int_{\xi_0}^1 \frac{d\xi}{\xi}\Big[e_c^2 f_{\frac{g}{P}}(\xi,\mu^2) c_{2,g}^{(0)} \Big] \\ &+ \frac{Q^2\alpha_s^2(\mu^2)}{\pi m_c^2}\int_{\xi_0}^1 \frac{d\xi}{\xi}\Big\{ e_c^2 f_{\frac{g}{P}}(\xi,\mu^2)\Big(c_{2,g}^{(1)} + \bar{c}_{2,g}^{(1)} \ln\frac{\mu^2}{m_c^2}\Big) \\ &+ \sum_{i=q,\bar{q}} f_{\frac{i}{P}}(\xi,\mu^2)\Big[e_c^2 \Big(c_{2,i}^{(1)} + \bar{c}_{2,i}^{(1)} \ln\frac{\mu^2}{m_c^2}\Big) \\ &+ e_i^2\, d_{2,i}^{(1)} + e_c\, e_i\, o_{2,i}^{(1)} \Big] \Big\} . \end{aligned} \quad (2)$$

The coefficient functions are of different origin: $c_{2,i}^{(1)}$ and $\bar{c}_{2,i}^{(1)}$ originate from the virtual photon-charmed quark coupling and appear for both charged and neutral parton-induced reactions; $d_{2,i}^{(1)}$ arise from the virtual photon-light quark coupling; $o_{2,i}^{(1)}$ come from their interference and do not contribute to F_2^c. Both the IC and EC components hold only in the DIS regime where $Q^2 > 0$.

We fit the EMC data with the sum of the EC and IC component of F_2^c. The normalization of both the IC and EC components are taken as free parameters,

$$F_2^c = \alpha F_2^{c,\mathrm{EC}} + \beta F_2^{c,\mathrm{IC}} , \quad (3)$$

with $\mu = \mu_0$. The shift in the normalization of the EC component may be considered as an estimate of the size of the NNLO contribution, equivalent to a shift in the scale μ. Since we have assumed a 1% normalization of the IC component, the fitted β is the fraction of this normalization. Our fitted value of β confirms the Hoffman-Moore result of an $\approx$ 0.3% IC contribution to F_2^c.

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[3] E. Hoffmann and R. Moore, Z. Phys. **C20** (1983) 71.

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*LBL-37266, ITP-SB-95-15, and FSU-HEP-951030; Nucl. Phys. **B461** (1996) 181.

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