Intrinsic Charm at High-Q^2 and HERA Data*

J. F. Gunion† *and R. Vogt*

HERA deep-inelastic scattering data with significant statistics at high Q^2 and high x is now becoming available [1]. The cross section exhibits an excess beyond the predictions based on standard QCD distribution functions. However, it is possible that unexpected contributions to the quark distribution functions might explain at least part of this excess. We study the implications of an intrinsic charm (IC) component of the proton [2] on the HERA data.

The possibility of an intrinsic charm component in the proton bound state has substantial theoretical and phenomenological motivation. However, a conclusive observation or severe limit has remained elusive. In the intrinsic charm model, there is a $|uudc\bar{c}\rangle$ component of the proton in which the c and $\bar{c}$ have become completely integrated members of the bound state, travelling coherently with the light quarks. The intrinsic charm Fock state probability distribution takes the form

$$\frac{dP_{ic}}{\prod_i dx_i} = \frac{N x_c^n x_{\bar{c}}^n}{(x_c + x_{\bar{c}})^n} \delta(1 - \sum_i x_i) \,, \tag{1}$$

with $n = 2$. However, since a more extreme dependence on the light-cone energy difference is possible, we also consider $n = 8$. The inclusive charm quark distribution, $c(x)$, is obtained by integrating Eq. (1) over all the x_i except $x \equiv x_c$. The intrinsic charm Fock state component of the proton is normalized to a 1% probability.

In order to compare to HERA data [1], we compute the ratio of intrinsic charm plus the standard model perturbative prediction from to the perturbative prediction alone as a function of Q^2 after integrating over $0.1 \leq y \leq 0.9$ and as a function of M after integrating over $y \geq 0.4$, where $M = \sqrt{xs}$ is the eq leptoquark mass.

The Q^2 dependence shows that the $n = 2$ and $n = 8$ IC models predict e^+p NC enhancements that grow to roughly 6% and 12%, respectively, at high Q^2. Much larger enhancements are indicated in the present HERA data. Relative enhancements in e^+p CC deep-inelastic scattering will be much larger, exceeding 60% and 150% at $Q^2 > 30000\mathrm{GeV}^2$ for the $n = 2$ and $n = 8$ IC models, respectively. Very small enhancements are predicted in e^-p CC scattering.

The (SM+IC)/SM ratios as a function of the leptoquark mass, M, are particularly revealing. The peak at moderate x values in the intrinsic charm distribution function results in a substantial peak in the (SM+IC)/SM ratio for e^+p NC scattering in the vicinity of $M \sim 200$ GeV, the same general location as the peak observed for data/SM by H1. Of course, the IC enhancement is much smaller than that observed. Other reactions could prove very valuable. For example, the peaking in (SM+IC)/SM as a function of M predicted by the IC models will be larger in e^+p CC scattering than in e^+p NC scattering.

We find that intrinsic charm is unable to explain enhancements in the e^+p neutral current cross section as large as those seen at HERA, although a small peak in the vicinity of leptoquark mass $M \sim 200$ GeV is a natural prediction. In the absence of other new physics, HERA data will ultimately provide a sharp test of the intrinsic charm picture.

[1] C. Adloff *et al.*, (H1 Collaboration), DESY 97-24 (hep-ex/9702012). J. Breitweg *et al.*, (Zeus Collaboration), DESY 97-25 (hep-ex/9702015).
[2] S.J. Brodsky, P. Hoyer, C. Peterson and N. Sakai, Phys. Lett. **B93** (1980) 451; S.J. Brodsky, C. Peterson and N. Sakai, Phys. Rev. **D23** (1981) 2745.

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†Davis Institute for High Energy Physics, Physics Department, University of California at Davis