Neutrino Dimuon Data and the Strangeness Content of the Nucleon

We have performed the first comprehensive global QCD analysis that includes the CCFR and NuTeV dimuon data, with a focus on exploring the entire strange and antistrange parton parameter space, which was not well-known before. We present several classes of solutions that are consistent with all relevant world data and the requirements of PQCD. In the x range of the dimuon data sets, $s(x) - \bar{s}(x)$ is found to be negative—in agreement with previous analyses. A common feature of all the allowed solutions is, however, that the strangeness asymmetry momentum integral $[S^-] \equiv \int_0^1 x[s(x) - \bar{s}(x))]dx$ is positive, and relatively large. This conclusion depends only on the qualitative features of the existing experimental data and the basic properties of PQCD. Applying the Lagrange-multiplier method to the full parameter space of the strangeness sector, we explicitly demonstrate that both the dimuon data and the other relevant world data sets strongly disfavor a negative value for $[S^-]$ in all consistent QCD parton models. These findings have immediate implications on QCD corrections to the Paschos-Wolfenstein relation, which is used in the precision determination of the Weinberg angle in neutrino scattering. (See the companion contribution.)

The Parton Structure of the Nucleon and Precision Determination of the Weinberg Angle in Neutrino Scattering

A recently completed next-to-leading-order program to calculate neutrino cross-sections, including power-suppressed mass correction terms, has been applied to evaluate the Paschos-Wolfenstein relation, in order to assess quantitatively the validity and significance of the NuTeV anomaly. In particular, we study carefully the shift of $\sin^2\theta_W$ obtained in calculations using $s = \bar{s}$ parton distribution functions (such as CTEQ6M) and those using a new generation of PDF sets that allow $s(x) \neq \bar{s}(x)$, enabled by recent neutrino dimuon data from CCFR and NuTeV. (See the companion contribution.)

This direct calculation confirms the expectation that the predicted value of $\sin^2\theta_W$ is closely correlated with the strangeness asymmetry momentum integral $[S^-] \equiv \int_0^1 x[s(x) - \bar{s}(x)]dx$. Since $[S^-]$ has been found to be positive and large for the new PDF sets, this implies a sizable negative shift of $\sin^2\theta_W$. This result is in the direction of bridging the difference between the NuTeV and the SM values of $\sin^2\theta_W$. The precise implications for the NuTeV anomaly will need to be determined after including detector-dependent corrections.

The results of this study, along with those of the companion contribution, suggest that the new dimuon data, the Weinberg angle measurement, and other global data sets used in QCD parton structure analysis can all be consistent within the SM.