Particle-and Antiparticle Asymmetry of the Nucleon Strange Sea

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An incomparable feature of the chiral quark soliton model (CQSM) as compared with many other effective models of QCD like the MIT bag model is that it can give reasonable predictions not only for quark distributions but also for antiquark distributions. This totally owes to the field theoretical nature of the model, which enables us to carry out nonperturbative evaluation of the parton distribution functions with full inclusion of the valence and the Dirac-sea quarks in the rotating mean field of hedgehog shape. This feature is also believed to play a decisive role in investigating hidden strange quark excitations in the nucleon, which entirely have non-valence character.

The main purpose of the present study is to give theoretical predictions for both of the unpolarized and the longitudinally polarized strange quark distributions in the nucleon on the basis of the CQSM generalized to the case of flavor SU(3), with careful account of the SU(3) symmetry breaking effects due to the mass difference between the strange and non-strange quarks. This effective mass difference Am. between the strange and non-strange quarks, being treated in a perturbation theory, is the only one additional parameter of the model necessary for the flavor SU(3) generalization. A particular emphasis is put on the flavor asymmetry of the sea quark distributions as well as on the particle-antiparticle asymmetry of the strange quark distributions, since they are believed to contain valuable in- formation on the nonperturbative dynamics of QCD at low renormalization scale.

As an example of our predictions, we show in Fig. I the ratio of a(x) and N(x) at Q' = 20 GeV2. Here, the solid and dashed curves are respectively the predictions of the SU(3) CQSM with and without the SU(3) symmetry breaking corrections, whereas the thin and thick shaded areas represent the phenomenologically favorable regions for this ratio, respectively obtained by CCFR group and by Barone et. al's global analysis. One clearly sees that the x dependence for this ratio is extremely sensitive to the SU (3) symmetry breaking effects and that the observed tendency is reproduced only after including it.

We have also investigated the longitudinally polarized distributions to find that the s-9 asymrnetry is much more profound for the polarized distributions than for the unpolarized ones. We also find that the predictions of the SU(3) CQSM for the longitudinally polarized distributions including the strange quarks are qualitatively consistent with the result of the recent elaborate analyses carried out by Leader, Sidorov and Stamenov.

As a final remark, the model is shown to give unique predictions also for the light-flavor sea- quark asymmetry exemplified by the quantities like $\bar{d}(x) - \bar{u}(x)/\ \bar{u}(x),\ \Delta\ \bar{u}(x) - \Delta\ \bar{d}(x)$.

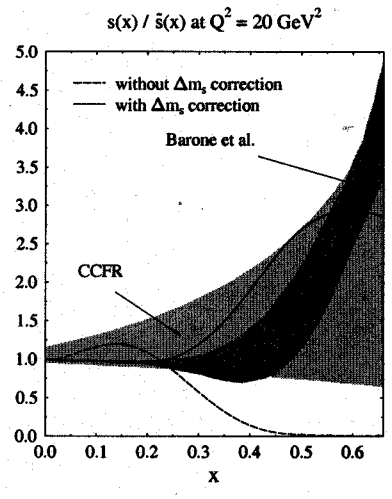

Figure 1. The theoretical predictions for the ratio $s(x)/\ \bar{s}(x)$ at $Q^2 = 20\ \text{GeV}^2$ with and without Δm_s corrections in comparison with the CCFR fit and Barone et al's global fit.