Instituto de Física
Universidade de São Paulo

Meson Cloud and $SU(3)$ Symmetry Breaking in Parton Distributions

Carvalho, F; Durães, FO; Navarra, FS; Nielsen, M; Steffens, FM
Instituto de Física, Universidade de São Paulo, CP 66318
CEP 05315-970. São Paulo. SP.Brasil

Publicação IF - 1435/2000

Meson Cloud and $SU(3)$ Symmetry Breaking in Parton Distributions

F. Carvalho[*], F. O. Durães[†], F.S. Navarra[‡],
M. Nielsen[§] and F. M. Steffens[¶]
Instituto de Física, Universidade de São Paulo
C.P. 66318, 05315-970 São Paulo, SP, Brazil

December 16, 1999

Abstract

We apply the Meson Cloud Model to the calculation of nonsinglet parton distributions in the nucleon sea, including the octet and the decuplet cloud baryon contributions. We give special attention to the differences between nonstrange and strange sea quarks, trying to identify possible sources of $SU(3)$ flavor breaking. A analysis in terms of the κ parameter is presented, and we find that the existing $SU(3)$ flavor asymmetry in the nucleon sea can be quantitatively explained by the meson cloud. We also consider the Σ^+ baryon, finding similar conclusions.

PACS numbers 14.20.Dh 12.40.-y 14.65.-q

---

[*] e-mail: babi@if.usp.br

[†] e-mail: fduraes@if.usp.br

[‡] e-mail: navarra@if.usp.br

[§] e-mail: mnielsen@if.usp.br

[¶] e-mail: fsteffen@if.usp.br

1 Introduction

The presence of a flavor asymmetry in the light antiquark sea of the proton is now clearly established [1, 2]. It can be expressed either in terms of the difference, $\Delta(x) = \overline{d}(x) - \overline{u}(x)$, or in terms of the ratio, $R(x) = \overline{d}(x)/\overline{u}(x)$. The fact that this difference is larger than zero (or that the ratio is larger than one) is usually referred to as $SU(2)$ flavor symmetry breaking in the proton sea.

We will discuss in this paper the nonperturbative origin of the breaking of flavor symmetry, both at the $SU(2)$ and at the $SU(3)$ level. To this end, we will study the suppresion factor of $\overline{u}$ antiquarks in the $SU(2)$ case, defined as

$$\kappa_{(2)} = \frac{\int_0^1 dx x\overline{d}(x,\mu^2)}{\int_0^1 dx x\overline{u}(x,\mu^2)}, \tag{1}$$

and the suppression factor of strangeness in the $SU(3)$ case:

$$\kappa_{(3)} = \frac{\int_0^1 dx[xs(x,\mu^2) + x\overline{s}(x,\mu^2)]}{\int_0^1 dx[x\overline{u}(x,\mu^2) + x\overline{d}(x,\mu^2)]}. \tag{2}$$

We notice that in the limit of exact $SU(2)$ ($SU(3)$) flavor symmetry $\kappa_{(2)} = 1$ ($\kappa_{(3)} = 1$). The CCFR collaboration has measured [3] $\kappa_{(3)} \simeq 0.37 \pm 0.05$ (0.477 ± 0.05) in a LO (NLO) QCD analysis. Uncertainties apart, it is clear that there is a substantial violation of the $SU(3)$ flavor symmetry. In the nonstrange light antiquark sector, the use of the standard parametrizations leads to $\kappa_{(2)} \sim 1.3$ [4, 5], indicating also a strong violation of the $SU(2)$ flavor symmetry in the proton sea. At the same time, the $SU(2)$ charge symmetry is believed to hold within the baryon octet, i.e., $\overline{d}(x) - \overline{u}(x)$ in the proton is equal to $\overline{u}(x) - \overline{d}(x)$ in the neutron. An interesting question is how $SU(3)$ charge symmetry is broken within the baryon octet. If the symmetry were exact, it would mean, for instance, that $s(x) - \overline{s}(x)$ in the proton should be equal to $d(x) - \overline{d}(x)$ in the Σ^+. However, as calculated by the authors of Ref. [7, 8, 9], this is not the case, and in this work we also investigate the origins of the breaking of this symmetry.

In QCD, exact $SU(3)$ symmetry implies that the u, d and s quarks have the same mass. Since the strange quark mass, m_s, is significantly larger than the up and down quark masses, the symmetry is only approximate. At the hadronic level, exact $SU(3)$ symmetry also implies that the masses of baryons or mesons belonging to the same multiplets are all equal. Clearly this is not the case and the masses within the baryon multiplets differ