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# ON CHIRAL SYMMETRY AND THE PION-NUCLEON INTERACTION IN THE SKYRME MODEL

by

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Abstract

The skyrme model realizes spontaneous chiral symmetry breaking in the Goldstone mode. This raises questions concerning the meaning of numerical results displayed in recent "phenomenological" applications.

Key-words: Skyrmion; Spontaneous chiral symmetry breaking; Goldstone realization.

Since some time ago several groups[1] renewed the interest on the Skyrme model[2] the main interest concerned low energy physics. A number of stimulating results were obtained[3,4] and, on the theoretical side it is widely believed that the lagrangean of the model will come out as an effective lagrangean of QCD[5].

In 1984, Schnitzer[6], starting from the lagrangean of the skyrme model, introduced the interaction with pions by making a chiral translation on it and expanding around the classical soliton solution up to order $\pi^2$.

$$U_{\pi N} = U_\pi U_o U_\pi \tag{1a}$$

$$U_o = \exp\,[iF(r)\vec{\tau}.\hat{r}] \tag{1b}$$

$$U_\pi = \exp\,\left[\frac{i\vec{\pi}.\vec{\tau}}{f_\pi}\right] \tag{1c}$$

The symbols are:

$\vec{\pi}$ : the pion field
$\vec{\tau}$ : the isospin generators
$f_\pi$: the pion decay constant
$F(r)$: the radial symmetric solution for the nucleon

The result of the procedure was a lagrangean having the form of a known chiral non linear lagrangean from which all the low energy pion physics is satisfactorily described (approximately). The coefficients, when comparing both expressions, yielded, from the term containing the nucleon isovector vector current:

$$\frac{1}{f_\pi} = \frac{g_V}{g_A}\,\frac{g_{NN\pi}}{2M_N} \tag{2}$$

$g_A$: axial vector coupling constant
$g_{NN\pi}$ pion nucleon constant
$M_N$ : nucleon mass

This is the celebrated Goldberger-Treiman relation. However, when the comparison is made for the coefficient of the axial vector current the result is:

$$g_A = g_V \tag{3a}$$

such that:

$$M_N = \frac{1}{2} g_{NN\pi} f_1 \tag{3b}$$

The expressions (3) tell that the rotated Skyrme lagrangean realizes the scenario of chiral symmetry breaking in the Goldstone mode, $f_\pi \neq 0$. This remains true even when a mass term for the pion is introduced. If fits properly in the description where SU(2) x SU(3) chiral symmetry is realized in Nature(7).

Coming back to the values quoted in the literature(3,4) integrating a numerically obtained "hedgehog" solution, they differ from the experimental values by a factor two. They do not agree either with the values from Eqs. (3a), (3b).

It has recently proposed by use of sum rules that the parameters of the Skyrme nodel would all be related to the chiral symmetry breaking $f_\pi$ (8). The point we raise is that the numerical values obtained(3,4) show an inconsistency. There is an urgent need to understand the way the numerical solution is linked to chiral symmetry breaking in order to have a clear idea about how reliable the numerical results might be.

It seems that there is no way to evade Schnitzer's construction and its conclusions, which do not depend on the from of F(r) in Eq. (1b), in order to have a meaningful description of low energy dynamics.

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