Comment on ''Octet baryon magnetic moments in the chiral quark model with configuration mixing''

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A recent paper by Linde, Ohlsson, and Snellman comes to the conclusion that a general ''sum rule for magnetic moments is always fulfilled in the chiral quark model, independently of SU(3) symmetry breaking.'' This conclusion is shown to be wrong because it does not take into account pion exchange currents, which must arise in any calculation of pion emission that is consistent with isotopic spin conservation.

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A recent paper [1] discusses the baryon magnetic moment sum rule [2]

$$\mu(p)-\mu(n)+\mu(\Sigma^-)-\mu(\Sigma^+)+\mu(\Xi^0)-\mu(\Xi^-)$$
$$=0 \quad (0.49\pm0.05). \tag{1}$$

This sum rule follows if non-static corrections to quark model calculations of baryon magnetic moments are baryon independent or SU(3) symmetric. The sum rule disagrees with the value [shown in parentheses in Eq. (1)] from experimental measurements [3] of baryon magnetic moments.

Reference [1] has presented the conclusion that the sum rule of Eq. (1) is not broken by arbitrary SU(3) symmetry breaking in the chiral quark model. However, the application of the chiral quark model in Ref. [1] leaves out important exchange effects that are as large as the effects considered in Ref. [1]. These exchange effects must enter in any model if conservation of isotopic spin is imposed at both the quark and the baryon level. Proper inclusion of exchange effects would produce a non-zero contribution to the sum rule of Eq. (1). The conclusion in Ref. [1] is also contradicted by an explicit calculation [4] of SU(3) symmetry breaking within a class of models that includes the chiral quark model.

Exchange currents would show up as the important process of a Goldstone boson being emitted by one quark and reabsorbed by a different quark in the same baryon. This emission and reabsorption would be equivalent to exchange currents, which should contribute to the baryon magnetic moments. Without this process, the Goldstone boson emission considered in Ref. [1] can only affect the effective anomalous magnetic moments of the quarks. Because the reabsorption of the Goldstone boson by a different quark is left out, the quark ''transition probabilities'' listed in Eqs. (A3)–(A5) of the Appendix of Ref. [1] do not depend on which baryon the quark is in. The transition probabilities in Ref. [1] are baryon independent in the sense of Ref. [2], and therefore the magnetic moments calculated in Ref. [1] satisfy the sum rule of Eq. (1).

An explicit example where the sum rule of Eq. (1) does not hold in a model that breaks SU(3) symmetry is given in Ref. [4]. There, the pions, because of their anomalously light mass, are taken to dominate the meson exchange currents, while *k* meson currents are left out. The pion exchange currents break SU(3), and the resulting baryon moments do not satisfy the sum rule of Eq. (1). For the quark model with pion contributions (including exchange), the prediction from the ''QM+pion'' column of Table I of Ref. [4] for the sum rule of Eq. (1) is 0.39, which is close to the experimental value.

The authors of Ref. [1] do conclude that configuration mixing of SU(3) symmetric gluons [5] or SU(3) symmetric diquarks [6] can produce a non-zero result for the sum rule of Eq. (1). This is surprising, because SU(3) symmetric mechanisms should not affect the sum rule. The reason that these mechanisms do give a nonzero contribution to the sum rule in Ref. [1] is that different mixing angles are arbitrarily chosen for different baryons in these cases, which breaks the SU(3) symmetry. The contribution of Goldstone boson (GB) emission can also be treated in terms of configuration mixing of the GBs in the same way as Ref. [1] does for gluons and diquarks. In fact, this is the method used in Ref. [4]. In the case of an SU(3) breaking GB admixture, the mixing angles are *required* to be different for baryons of different strangeness because of the pion exchange mechanism discussed above. This is another way to see that breaking SU(3) symmetry in the emission of Goldstone bosons must break the sum rule of Eq. (1).

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