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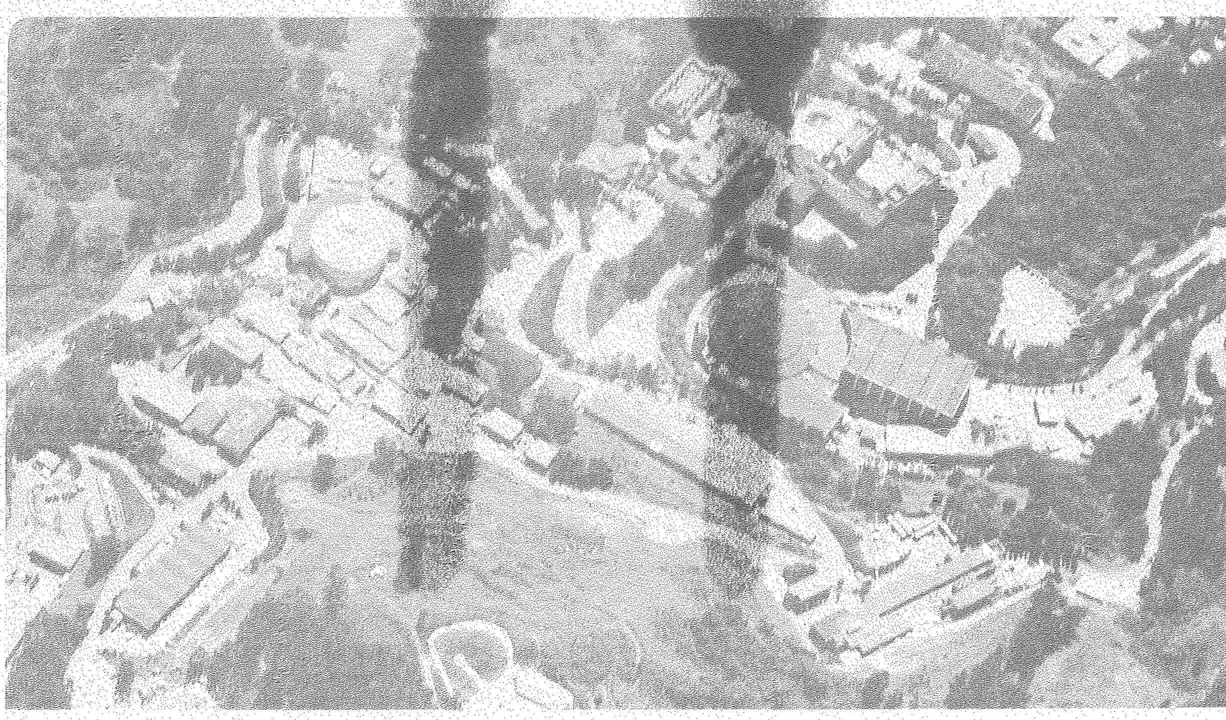
April 1981



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Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

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BARYON MAGNETIC MOMENTS FROM TOPOLOGICAL THEORY*

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An early quark-model success was the qualitative explanation of baryon magnetic-moment ratios,[1] although later it became appreciated that the predicted ratios do not agree quantitatively with the naive quark model.[2] Recently there has been proposed a new theory of hadron electromagnetic properties[3] which extends the dual topological theory of strong interactions.[4] This theory bears some similarity to the quark model, but there are important differences which radically affect the magnetic moment picture: Topological "quarks" carry integral rather than fractional charge and do not individually carry momentum; part of a baryon charge resides not in quarks but in a "core". The entire spin content of a baryon nevertheless is carried by topological quarks. In this note we report a preliminary calculation of baryon magnetic moments based on the theory of Ref. [3].

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* This work was supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Division of High Energy Physics of the U. S. Department of Energy under Contract No. W-7405-ENG-48.

** Participating guest at Lawrence Berkeley Laboratory.

In the latter theory electromagnetic amplitudes consist of an infinite sum of terms of increasing topological complexity. The first term in the expansion (the analogue of the "planar" component of meson strong-interaction dual topological models[5]) has been called the "minimum entropy" component, and all successive terms are in principle calculable once minimum-entropy terms are prescribed. We present here the minimum-entropy contribution to baryon magnetic moments, together with an estimate of the higher-entropy contributions.

Minimum-entropy amplitudes have the spin-flavor structure expected from a constituent model. The baryon constituents are three integrally-charged spin-$\frac{1}{2}$ topological objects which we call "quarks" and a spin-zero object carrying electric charge −1 which we call a "core". The spin-flavor wave functions of the quarks in a baryon are the same in topological theory as in the standard fractional-charge model; the proton, for example, consists of 2 u quarks each of charge +1, one d quark of charge 0 and a core of charge −1. These "constituents" however, do not carry energy or momentum.

Calculation of the minimum-entropy contribution to hadron magnetic moments is simple. The core, being spinless, does not contribute. A quark of charge q and spin vector $\vec{\sigma}$ in the baryon rest frame contributes $\frac{q}{2m_o}\vec{\sigma}$ to the magnetic moment; here m_o is the "zero-entropy" <u>hadron</u> mass, reflecting the absence in topological theory of any "quark-mass" notion. Although m_o is not equal to any <u>physical</u> hadron mass, it is supposed that m_o approximates the mass of low-mass "elementary" hadrons such as the nucleon and the ρ meson.* Given a value for m_o together with the above expression for a topological quark magnetic moment, it is straightforward to compute the values (not just the ratios) of hadron magnetic moments. For the proton this calculation gives 4/3 in units of $\frac{e}{2m_o}$ while for the neutron it gives $-\frac{1}{3}$. These values appear in the last column of Table I together with the corresponding values for other members of the baryon octet. (The topological strange quark has zero charge.) Measured baryon magnetic-moment values, in units of $\frac{e}{2m_p}$ where m_p is the proton mass, are given in the first column.

It is seen that, even allowing for some difference between m_o and m_p, the agreement of minimum entropy with experiment is not close, although the order of magnitude and general trend are correct. This circumstance is not surprising because the magnetic-moment interaction vanishes at $q = 0$ ($p_\perp = 0$) and the topological expansion depends for its convergence on phase coherence associated with low momentum transfer. Low-$p_\perp$ electromagnetic interactions are dominated by the electric charge (correctly given by minimum entropy), with the magnetic-moment contribution being a small correction.

As it becomes better understood how to calculate higher-order contributions from the topological expansion, it may be hoped that the agreement between magnetic-moment measurements and topological-theory prediction will systematically improve. For the present we propose the following estimate of these contributions: At minimum

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* The physical π-meson mass is believed to be substantially smaller than m_o because of unusually-large higher-order contributions from the topological expansion.

entropy "elementary" hadrons have "intrinsic" magnetic moments, such as listed in the last column of the table; there is no electromagnetic structure corresponding to an "anomalous" magnetic moment. Anomalous moments of physical hadrons correspond to higher entropy. Since topological theory is founded on analyticity properties of the S matrix, it is plausible to estimate anomalous moments through the "classical" analytic S-matrix approach of assuming dominance in electromagnetic structure functions by lowest-mass singularities. For the proton and neutron this is well known to mean the 2π channel in the sense of Fig. 1(a). It is important to appreciate that the topological expansion classifies such a contribution as being <u>of higher order</u>. The intrinsic "elementary proton" moment of $\frac{4}{3}\frac{e}{2m_o}$ is separate and distinct from such contributions--whose topological complexity prevents contraction to the topology of minimum entropy.[3] (The foregoing statements do not preclude a vanishing at large q^2 of the physical proton electromagnetic form factors.)

The $\pi\pi pp$ vertex in Fig. 1(a) can be approximated, according to duality, <u>either</u> by a ρ pole in the $p\bar{p}$ channel <u>or</u> by a baryon pole in the πp channel. We are interested in the neighborhood of zero photon momentum, and the latter approximation turns out to be more appropriate, corresponding to Fig. 1(b). In the "classical" spirit of low-energy dominance we here do not include the Δ pole. That is, we think of the most probable proton "structure" as arising from its dissociation into the "nearest" communicating channel--a neutron plus a π^+-- with the π^+ then absorbing the photon. The measured value of the $p \to n\pi^+$ coupling constant leads to a proton magnetic moment contribution of $1.67 \frac{e}{2m_p}$, as was computed long ago.[6] This number we take as our estimate of the correction to minimum entropy.

The corresponding pionic correction to the neutron magnetic moment is $-1.67\frac{e}{2m_p}$, and one sees from Column 2 in Table I that such corrections have the magnitude and sign needed to improve agreement with experiment. Column 2 gives, in units of $\frac{e}{2m_p}$, the intrinsic proton and neutron moments if the anomalous moments were exactly ± 1.67. The numbers in Column 2 are seen to be reasonably close to the predicted intrinsic moments if m_o is not far from the proton mass.

The observed magnetic moments of other baryon-octet members can be similarly "corrected" for structure. The estimates of Column 2 are made, as above, by considering the "nearest" baryon-meson channels. (For the meson-baryon coupling constants we used SU(6) values, which are thought to be reasonably adequate.) Thus for μ_Λ we consider $\Lambda \to p + k^-$; for μ_{Σ^-} we consider $\Sigma^- \to \Sigma^0 + \pi^-$, $\Sigma^- \to \Lambda + \pi^-$ and $\Sigma^- \to n + k^-$, etc.

Although it remains to be shown that higher-order components of the topological expansion actually agree with the estimates made here, we find encouraging the comparison between Columns 2 and 3 of the table. This comparison shows that topological theory, even though it has integral quark charges, *may* eventually yield the correct values for hadron magnetic moments.

One of us (J. F.) acknowledges the hospitality of the LBL theoretical group. We are indebted to M. Suzuki for helpful discussions.

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TABLE I

Particle	$\mu_{exp} / \frac{e}{2m_p}$	μ_{exp} minus "lowest" meson contrib.	$\mu_{min.\ entropy} / \frac{e}{2m_o}$
p	2.79	1.12	$\frac{4}{3}$
n	-1.91	-0.24	$-\frac{1}{3}$
Λ	-0.61	-0.08	0
Σ^+	2.33 ± .13	1.40 ± .13	$\frac{4}{3}$
Σ^-	-1.41 ± .25	-0.43 ± .25	0
Ξ^0	-1.20 ± .06	-0.34 ± .06	$-\frac{1}{3}$
Ξ^-	-1.85 ± .75	-1.26 ± .75	0

Table I: Baryon magnetic moments. First column gives experimental values as listed in the Particle Data Tables. Second column (in same units as first) includes our estimate of "structure" correction. Third column is the minimum-entropy prediction for the quantity in the second column--the "intrinsic" baryon magnetic moment.

FIGURE CAPTION

Calculation of the proton magnetic moment by approximating the higher-entropy terms by the contribution of the 2π channel.

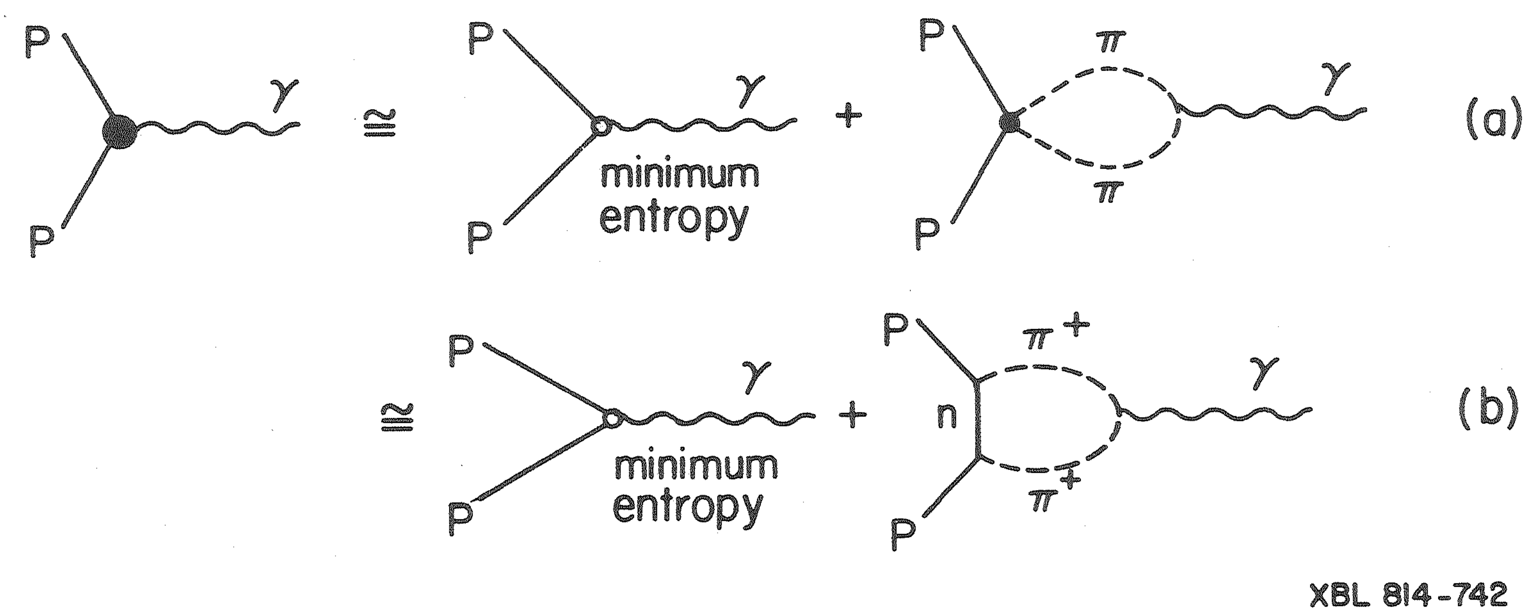

FIGURE 1