# A phenomenological magnetic description for the origin of mass for leptons and for the complete baryon octet

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PACS: 03.65.Sq; 12.39.-x
Keywords: zitterbewegung, mass, leptons, baryons

## Abstract

In the late 1970s A.O.Barut put forth an alternative theory for the inner constitution of baryons and mesons, in which the basic pieces would be the stable particles, namely the proton, the electron, and the neutrino, rather than quarks with fractionary charges. At the same time Barut proposed also that the short range strong interactions between such internal constituents would be magnetic in nature. Quite recently, in vixra 1511.0005, we developed a phenomenological model based upon the concept that the magnetodynamic energy of zitterbewegung intrinsic motion is the source for the rest energies, and therefore, the source of mass in particles. In the present paper we show that our recently proposed model can be applied to leptons and to the full baryon octet with almost perfect accuracy, in a way consistent with Barut´s proposal. It is shown that mass for all these particles depends on two quantities, namely, the number of magnetic flux quanta trapped in an intrinsic vibrational motion, and the magnetic moment of the particle.

**Introduction**

This paper builds upon the recent work by the author, vixra 1511.0005[1], which should be consulted for details. In that paper, beginning from the concept of gauge invariance and accepting as true the zitterbewegung intrinsic motion of fundamental particles, as discussed by Barut and Bracken[2] among others, we associated the magnetodynamic energy of the motion with the rest energy of a particle. The main result of such analysis was eq. (3) of [1]:

$$\frac{mR^2}{\mu} = \frac{nh}{2\pi ec} \tag{1}$$

In this equation *m* is mass, *R* is the range of the vibrational intrinsic motion of the particle, $\mu$ is the magnetic moment, *n* is the number of magnetic flux quanta( admitted as given by the nonrelativistic expression *hc/e*). The model adopts experimental values for *m* and $\mu$. For the nucleons *R* was given by theoretical values calculated by Miller[3], and for the electron (and now the muon) this parameter was assumed as equal to the Compton wavelength $\lambda = \hbar/mc$[2]. Good agreement between model and experiment was obtained for that reduced group of particles.

However, the application of the model to other particles depends on the knowledge of the parameter *R*. In order to put the model to further test, in the present work we decided firstly to simply try and eliminate the explicit dependence of the model upon *R*. For the leptons the following expression is known to be valid:

$$\mu = e\lambda/2 \tag{2}$$

Here $\mu = \mu_B$ is the magnetic moment in the case of the electron ($\mu_B$ is the Bohr magneton; here we consider no further corrections). Therefore, for the remaining members of the baryon octet considered in this work we will *assume* that in (2) $\lambda/\sqrt{2}$ can be directly replaced by *R*, so that *R* is eliminated from (1) in favor of $\mu$. It is clear that such possiblity associates mass to only two parameters, namely, the number of flux quanta imposed by gauge invariance conditions and the charges of the constituents inside the baryons, and to the inverse of the experimental magnetic moment. As shown below we verify that such proposal is consistent with experiment.

Inserting the definion for $R$ into (1) and using the definition of the fine structure constant $\alpha= e^2/\hbar c$ (which we assume as 1/137) we can rewite (1) in the form:

$$\frac{2c^2\alpha}{ne^3}m = \frac{1}{\mu} \qquad (3)$$

**Application to Leptons and Baryons**

A.O.Barut [4,5] proposed an alternative theory for the inner constitution of baryons and mesons, in which the basic pieces would be the stable particles, namely the proton p, the electron $e^-$, and the neutrino ν( ν´will indicate antineutrinos, below), rather than quarks with fractionary charges( as assumed by us in [1]). At the same time Barut proposed also that the short range strong interactions between such internal constituents would be magnetic in nature. In order to account for the same conservation rules as a model based upon the fractionary quarks does, the constitution of baryons should be as follows[4,5]: proton =p= (p $e^-$ $e^+$), neutron=n= (p $e^-$ ν´), $\Sigma^-$ =(p $e^-$ $\mu^-$ ν´ ν´), $\Sigma^0$ =(p $\mu^-$ ν´), $\Sigma^+$ =(p $e^+$ $\mu^-$ ), $\Xi^-$ =(p $\mu^-$ $\mu^-$ ν ´ν´), $\Xi^0$ =(p $\mu^-$ $\mu^-$ $e^+$ ν ´), Λ =(p $\mu^-$ ν ν ´ν´). We see that the proton is present in all baryons but is itself a composite particle, supposedly containing an electron and a positron. The analysis below shows that assuming Barut´s ideas are correct, our recently proposed model can be applied to leptons and to the full baryon octet with almost perfect accuracy. However, the precise values of $n$, the number of flux quanta in (3), are actually unknown. The determination of these numbers would require the knowledge of the proper topological properties of each baryon and its constituents. Relativistic effects if relevant would certainly also have an effect on these numbers. A previous attempt, in a model that also relates particles to zitterbewegung was proposed by Jehle[6], associating particles to the topology of torus knots. Instead of a single $n$ Jehle associates flux quantization to a complicated combination of winding and whirling numbers. However, in the spirit of a phenomenological model, in Table 1 we simply notice that the magnetic moments for the baryons in the last column are almost perfectly ordered proportionally to integer or half-integer numbers, which are shown in the middle column, and which we empirically choose as the proper $n$. At least one of these numbers, $n$=3 for the proton, can be justified in simple terms but assuming spin-1/2 quarks as forming the proton. In a previous ( unpublished) calculation based upon an average over the three different quarks spins configurations weighted by their Clebsch-Gordan coefficients, we obtain exactly $n$=3 flux quanta for a proton. For the other baryons listed above there is clearly no hint on how to make the appropriate combinations for the compositions proposed by Barut, in view of the number of particles and also the presence of chargeless neutrinos which adds to the uncertainty of any theoretical evaluation. However, the proposal by Barut of adopting stable particles of unitary or null electric charges as the constituents of baryons actually lends support to a calculation such as that proposed here, since the uncertainty about the actual properties of quarks turns the very proposal of a conventional wavefunction to represent them open to questioning, as shown in the papers by Jehle.

Table 1 displays the empirical values of $n$ and the other data utilized in the analysis. The magnetic moment data are from [7].

**Analysis**

Figure 1 shows the plot of eq.(3) and the straight solid line would indicate perfect agreement with theory. We observe the following:

1) Equation (3) describes perfectly well the data available for leptons ( triangles) and baryons with the values of $n$ in Table 1.

However

2) The quantization rules adopted in this model[1] clearly correspond to a nonrelativistic limit. Such rules certainly depend on other symmetry properties of these particles associated with the SU(3) group, for instance. Such details lay beyond the scope of this treatment.

The influence of topology( introduced through the concepts of flux quantization and gauge invariance) is evident in view of the importance of the empirical sequence of values for $n$ in Table1, and their clear association with the actual magnetic moment data, which can only be interpreted in such geometrical terms.

There exists a wealth of references in the literature in which scaling laws are proposed based[8-10] on experimental results, to associate mass for all particles with the inverse of $\alpha$. We see from (3) that such relation with $\alpha$ indeed is part of our results. In particular, the results of [10] might be reproduced if the ratio $n/\mu$ in (3) is made part of the *free* parameter N in ref. [10].

In resume, this paper has shown that if one properly inserts quantum conditions in a closed-orbit intrinsic motion for the fundamental particles ( even in a nonrelativistic limit), in order that gauge invariance is introduced in the treatment, the masses for these particles are directly dependent only upon the inverse of their magnetic moments and upon the number of magnetic flux quanta inside the orbits. This demonstrates the influence of geometrical or topological effects on the problem of mass determination. On the other hand a model like this is only justifiable if baryons are formed by the combination of bonafide stable particles of unitary or null electronic charge, as proposed by Barut, since the introduction of quarks instead would bring in the usual uncertainties related to their formal description in terms of conventional wavefunctions, and so on.

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Table 1: Data utilized in Figure 1. The values of *n* are chosen as the integer or half-integer numbers that follow as close as possible the ( apparent !) sequence in the last column for the baryons, in order to fit theory to data. The magnetic moments are from ref. [7]. One needs to convert mass to grams, magnetic moments to erg/gauss ( all CGS units).

| part | Rest energy(MeV) | n | (Abs)Magnetic moment( n.m.) |
|---|---|---|---|
| e | 0.511 | 1 | 1836 |
| muon | 105.66 | 1 | 8.89 |
| p | 938.27 | 3 | 2.79 |
| n | 939.56 | 2 | 1.91 |
| Σ + | 1189 | 2.5 | 2.46 |
| Σ 0 | 1192 | 1 | ~0.7( theor.) |
| Σ − | 1197 | 1.5 | 1.16 |
| Ξ 0 | 1314 | 1.5 | 1.25 |
| Ξ − | 1321 | 1 | 0.65 |
| Λ | 1116 | 0.5 | 0.61 |

Figure 1: Plot of eq. (3). The dotted lines indicate a factor of 2 around the solid line. Triangles are leptons and circles are baryons.