We propose that the magnetic moment formulae of baryons may be determined by quantum numbers. This is a new type of magnetic moment formula, and also agrees better with CBM calculation (Thomas et al., 1981; and Thunberg et al., 1982) and with the experimental values. It is also similar to corresponding mass of formulae of hadrons.

**Keywords:** Baryon, Magnetic moment, Quantum number

**INTRODUCTION**
Magnetic moments have played a major role in the development of our current understanding of the structure of matter. The Zeeman effect and the Stern-Gerlach experiments were crucial to modern ideas of angular momentum, spin quantum mechanics and atomic structure. Extraordinarily precise measurements. The magnetic moments of the electron muon have supported the validity of quantum Electrodynamics and established that, these charged leptons behave as point like Dirac particles. If the lessons of the past are any guide, precise measurements of baryon magnetic moments will provide as with constraints on models of hadronic structure, and important information about the nature of the constituents of hadrons.

The large anomalous moments for the neutron, proton have shown that these particles are not elements. Our knowledge of hadrons’ magnetic moment calculation comes mostly from models: Skyrme model, string models, the Nambu-Jona-Lasinio model to name a few. Though all the models are made to fit the hadron magnetic moment, they differ considerably on its origin.

The phenomenology of constituent quark dynamics in hadrons has been reasonably successful through the bag model approach (McCall, 1980). Yet this model is believed to be neither unique nor entirely free from difficulties and objections. Hence here have been in the recent past several attempts to formulate various alternative schemes with phenomenological potentials of appropriate Lorentz structure, scalar – Vector potentials in the linear (Oset et al., 1984) Harmonic

---

1. PG Department of Physics, Berhampur University, Bhanjabihar 760007.
2. Mathematics and Science Department, SMIT, Brudaman Bihar, Ankuspur.
3. Electronics Department, Science College, Hinjilicut 761102.

This article can be downloaded from http://www.ijerst.com/currentissue.php
and cubic form (Leal Ferreira, 1977) and equally mixed scalar-vector potentials in the linear (Leal Ferreira, 1977) harmonic (Barik et al., 1985) and logarithm (Jena and Rath, 1986), non-coulombic power-law form (Barik and Jena, 1980) have been investigated by various authors. All these models, used in a limited baryonic sector, only meet with a success more or less identical to that of the bag model. These models connect necessarily with the structure and internal interactions of particles. Therefore the magnetic moment formula of baryons is still an opinion and a researched question from various aspects (Verma, 1980; Ioffe and Smilga, 1984; Karle, 1992; Pondrom, 1996; Bains and Verma, 2002; Lebed and Martion, 2004; Mekhfi, 2005; and Linde et al., 1998), which included quark mass, rotation, QCD, Lattice, Field theory and string theory, etc. Some models are complex.

Applied an analogous method of mass formula of hadrons determined by quantum numbers, for example, the Gell-Mann-okubo mass formula, we propose a new type of magnetic moment formula for baryons determined by quantum numbers.

THEORETICAL FRAME WORK

First we propose that the magnetic moment formulas of baryons may be determined by quantum numbers and the first formula is

\[ \mu = [\mu_0 + aQ(Q+1) + bU(U+1)I + cS]\mu_n \]  

...(1)

Applied an analogous method of mass, where

\[ \mu_n = \frac{eh}{2m_p} \] is a magnetic moment of Proton. It agrees qualitatively with data except \( \Sigma^0 \) when \( \mu_0 = -0.943, a = 2.05, b = -0.488, c = 0.33 \).

Next, the second magnetic moment formula is:

\[ \mu = [\mu_0 + aQ(Q+1) + bU(U+1)I + cS]\mu_n \]  

...(2)

It agrees better with data, when \( \mu_0 = -0.943, a = 2.05, b = -0.488, c = 0.33 \)

Third, we introduce a composed quantum number

\[ \overline{U} = I + 0.5|\gamma| - |Q| \]  

...(3)

Which is namely the values of \( U \) spin for \( U(\Lambda) = 0 \) and \( U(\Sigma^0) = 1 \), such the magnetic moment of the \( J^p = \frac{1}{2}^+ \) baryon octet my classify four groups.

\[ \overline{U} = 0 \] singlet (\( \Lambda \)), two \( \overline{U} = \frac{1}{2} \) doublet (\( P, \Sigma^+ \)) and \( \Xi^-, \Sigma^- \) \( \overline{U} = 1 \), triplet \((\Xi^0, \Sigma^0, n)\).

The experimental values seem to show that various magnetic moments of baryon octet are classified according to two quantum numbers charge \( Q \) and \( \overline{U} \). Then assuming that the magnetic moments are positive for baryons with \( Q = 1 \) while the magnetic moments are negative for baryons with \( Q = 0 \) or 1. So, we propose an absolute value formula of the magnetic moment for baryon (Yi-Fang Chang, 1995).

\[ |\mu| = A(Q(Q+1)+\frac{S}{2}) + B(\overline{U} + 1) \]  

...(4)

The magnetic moments take also absolute value \( i \) quark model. Linde, Puglia and Dahiya et al. (1998), discussed magnetic moments of \( 3/2 \) resonances and decuplet (Theberge and Thomas, 1982; Kreissl et al., 1988; and Yao et al., 2006). When the magnetic moment Equation (4) is extended to the \( J^p = \frac{3}{2}^+ \) = baryon decuplet, It should add a spin-term, namely

\[ |\mu| = A(Q(Q+1)+\frac{S}{2}) + B(\overline{U} + 1) + cJ(J+1) \]  

...(5)
This is also similar formula of corresponding baryons.

**CALCULATION AND RESULTS**

We choose the parameters $A = 0.679$ and $B = 0.9565$, we obtain the theoretical values.

In the Table 1, we compare the experimental values (Linde and Snellman, 1996) and CBM results (Puglia and Ramsey, 2000) with some theoretical results.

Comparison of the experimental values of magnetic moments with same theoretical results.

However, there is a simple relation between two constants in Equation (4) as:

$$ B/A = 1.409 \approx \left(\mu_p / \mu_n\right) = 1.460 \approx \frac{3}{2} $$

Further, many relations of baryon magnetic moments may be obtained based on the relations of quantum numbers. For example, using Equation (4) we may derive the following results.

$$ 2\mu(\Lambda) + \mu(\Sigma^0) = \mu(n) + 2\mu(\Xi^-) = (-4.446 \pm 4.413) $$

$$ 3\mu(\Lambda) + \mu(\Sigma^0) = \mu(n) + 2\mu(\Xi^-) = (-3.446 \pm 3.214) $$

$$ \mu(n) + \mu(\Xi^-) = 2\mu(\Sigma^0) = (-3.163 \pm 3.22) $$

$$ \mu(\Lambda) + \mu(\Sigma^0) = \mu(\Sigma^-) + \mu(\Xi^-) = 3\mu(\Lambda) $$

$$ = -1.863 \pm 1.811 \pm 1.819 $$

$$ \mu(p) + \mu(\Sigma^0) = \mu(\Sigma^-) + \mu(\Xi^-) = -1.1828 \pm 1.208 $$

$$ |\mu(p)| + |\mu(\Sigma^0)| = |\mu(\Sigma^-)| + |\mu(\Xi^-)| = 4.0428 \pm 4.068 $$

Perhaps, the magnetic moments of antiparticles are only opposite value with corresponding particles, for example, $\mu(P) = -2.8005$) $\mu(n) = \mu(P)$ for negative Proton (Pahiya and Gupta, 2003).

Equation (5) is also similar to the mass formula of corresponding baryons If $A$ and $B$ are the same values, i.e., $A = -B = B$, we will obtain $C = 1.0692$ since $\mu(\Omega^-) = -2.02 \pm 0.05$ (Kreissl et al., 1988). Then other magnetic moments of decuplet baryons are predicted.

**Table 1: Comparison of the Experimental Value of Magnetic Moments with Some Theoretical Values**

<table>
<thead>
<tr>
<th>$\mu(B)$</th>
<th>Formula (1)</th>
<th>Formula (2)</th>
<th>Formula (4)</th>
<th>CBM (40)</th>
<th>Expt 39</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P$</td>
<td>2.793</td>
<td>2.793</td>
<td>2.7928</td>
<td>2.60</td>
<td>2.7928</td>
</tr>
<tr>
<td>$N$</td>
<td>-1.913</td>
<td>-1.913</td>
<td>-1.9130</td>
<td>-2.01</td>
<td>-1.9130</td>
</tr>
<tr>
<td>$\Lambda$</td>
<td>-0.613</td>
<td>-0.613</td>
<td>-0.6170</td>
<td>0.58</td>
<td>-0.613±0.004</td>
</tr>
<tr>
<td>$\Sigma^+$</td>
<td>2.759</td>
<td>2.463</td>
<td>2.4533</td>
<td>2.34</td>
<td>2.458±0.010</td>
</tr>
<tr>
<td>$\Sigma^0$</td>
<td>-2.553</td>
<td>-1.583</td>
<td>-1.5735</td>
<td>-</td>
<td>-1.61±0.00</td>
</tr>
<tr>
<td>$\Sigma^-$</td>
<td>-1.341</td>
<td>-0.977</td>
<td>-1.0953</td>
<td>-1.08</td>
<td>-1.16±0.025</td>
</tr>
<tr>
<td>$\Xi^0$</td>
<td>-1.253</td>
<td>-1.253</td>
<td>-1.2340</td>
<td>-1.27</td>
<td>-1.25±0.0M</td>
</tr>
<tr>
<td>$\Xi^-$</td>
<td>-0.647</td>
<td>-0.647</td>
<td>-0.7558</td>
<td>-0.51</td>
<td>-0.650±0.0025</td>
</tr>
</tbody>
</table>

**Table 2: Prediction of Magnetic Moments of Decuplet Baryons**

<table>
<thead>
<tr>
<th>$\Delta^+$</th>
<th>$\Delta^-$</th>
<th>$\Delta^0$</th>
<th>$\Delta^-$</th>
<th>$\Sigma^+$</th>
<th>$\Sigma^-$</th>
<th>$\Xi^+$</th>
<th>$\Xi^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3/2</td>
<td>2</td>
<td>3/2</td>
<td>1/2</td>
<td>1</td>
<td>1/2</td>
<td>1/2</td>
</tr>
<tr>
<td>6A + 2B + 1.5C</td>
<td>2A + 2B + 1.5C</td>
<td>3B + 1.5C</td>
<td>2.5B + 1.5C</td>
<td>1.5A + 2.5B + 1.5C</td>
<td>-0.5A + 2B + 1.5C</td>
<td>-0.5A + 1.5B + 1.5C</td>
<td>-A + 2B + 1.5C</td>
</tr>
</tbody>
</table>
Magnetic moments of decuplet baryons

Of course, in formula (5) A (or) B are also probably different or combined spin J, the quantum number $\tilde{U}$ may be extended.

CONCLUSION

In our earlier work (Barik et al., 1985) we have found that an independent quark model based on the Dirac equation with an equally mixed scalar-vector linear confining potential provide a simple and straight forward approach for the study of static properties of light, charmed and b-flavoured baryons in a flavour independent manner. In the present work, we have given a new type of magnetic moment formula which is independent to the constituents, structures and interactions inside the baryons, and is similar to the corresponding mass formula of hadrons.

Such studies from various quark-models when extended to describe hadronic properties in such a wide sector may provide an opportunities to resolve the question regarding the true nature of quark confinement which is not straightforward to conclude on purely theoretical grounds based on Quantum Chromodynamics (QCD).

ACKNOWLEDGMENT

The authors are thankful to Retd. Prof. S N Jena, PG Department of Physics, Berhampur University, for his inspiration and valuable suggestions.

REFERENCES


