THE APPLICATION OF BOHR AND SOMMERFELD METHODS IN THE THEORY OF MAGNETIC QUARK MODELS

by

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A B S T R A C T

This paper calls attention to a common mistake concerning the applicability of semi-classical methods in the calculation of the energy levels in a system of two or more magnetic monopoles in orbit about each other. The notion that the interaction forces are far too strong to allow a calculation of several innermost (troublesome) energy levels by the Bohr and Sommerfeld method, overlooks the fact that these troublesome orbits are inside a distance equal to the classical radius of the magnetic monopoles involved,where the magnetic interaction forces are far lower; according to classical theory, than their coulombian values. By taking into account the lower value of the interaction forces inside the classical radius distance, it is easy to calculate many of the troublesome orbits and energy levels by data processing machines.

Results obtained by this method, which were presented in two earlier papers (Barricelli 1978 A and B), are summarized. The results include the theoretical calculation of the masses of about 30 elementary particles.

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1. Introduction

The aim of this paper is to call attention to a fundamental and unfortunately very common mistake concerning the applicability of Bohr and Sommerfeld methods in the calculation of energy levels in a system formed by two or more magnetic monopoles in orbit about each others. The large size of magnetic monopole charges, which accordnig to Dirac (1931) are expected to be multiples of an elementary charge g, hereafter designated as the "Dirac monopole", given by the formula

(1) $g= \frac{1}{2}\sqrt{137\ \hbar c}= \frac{137}{2}\ e$

e= charge of the electron

c= velocity of light

$\hbar= \frac{h}{2\pi}$, h being Plank's constant

has led to the belief (see below) that not only in wave mechanics but also in semi-classical (Bohr and Sommerfeld) quantization theory, the magnetic fields involved are far too strong to make possible a calculation of energy levels.

The argument goes as follows. The angular momentum of a system of two magnetic monopoles of charges g_1 and g_2 respectively assumed to be moving for example, in circular orbits about a common center of gravity is given by:

(2) $$A= \frac{g_1 g_2}{v_1+v_2} = M_1 v_1 r_1 + M_2 v_2 r_2$$

v_1 and v_2 being their respective velocities, M_1, M_2 their respective masses, r_1, r_2 their respective distances from the center of gravity. Bohr's quantization formula A=nh gives then:

(3) $$v_1+v_2= \frac{g_1 g_2}{n\hbar}$$

n being an integer identifying the energy level. If the magnetic charges g_1 and g_2 are equal to or larger than the Dirac monopole given by formula (1), the sum v_1+v_2 of the two velocities, would become, according to formula (3):

(4) $$v_1+v_2 \geq \frac{137}{4n} c$$

This value becomes more than twice the speed of light for every energy level with $n< \frac{137}{8}$; meaning for all of the energy levels n=1,2,3 ... 17, at least one of the velocities v_1, v_2 would have to be greater than the speed of light. As a result the relativistic formula identifying the bindings energy gives imaginary or complex energy values for all of these levels. This applies not only for the Bohr and Sommerfeld formula when duly corrected for relativistic effects, but also for Dirac's and other relativistic wave mechanical formulas for the calculation of energy levels (see Barricelli 1978 A).

Because of these difficulties, meaningful bindings energies have been considered virtually unobtainable with presently available methods for magnetic monopoles. A typical attitude towards this subject is reflected by the following kind of pronouncement some times found in the literature: "Valid quantitative calculations of bindings energies have not been obtained yet. Because of the strong forces acting between the magnetic charges it is difficult with the present theory to make reliable calculations." Similar considerations are offered by Schwinger (1968) and others. Moreover the same attitude concerning the calculation of energy levels is quite general also in connection with other theories and other hypothetical fields considered responsable for the interactions between the components of elementary particles (quarks, and other partons). All attempts to calculate energy levels and masses of elementary particles have been quelled or seriously hampered by this sort of considerations.

2. The overlooked opportunity.

As far as the applicability of semi-classical models is concerned, the argument presented above has a fundamental flaw. The fact whose implications seem to have been overlooked so far is that all of the 17 energy levels in which the problem of complex bindings energies arises (troublesome energy levels) are connected with orbits whose semi major axis $a_n = \frac{2n^2\hbar^3}{g^2M} = \frac{32n^2g^2}{137^2MC^2}$ (for $g_1-g_2=g$ and $M_1=M_2=M$) is smaller than the classical radius $r_0 = \frac{g^2}{MC^2}$ of the magnetic monopole. Inside the classical radius distance the magnetic potentials and the forces acting upon the charges can be far lower, according to classical electromagnetisms, than the strictly coulombian ones calculated on the point charge assumption, and the magnetostatic forces approach 0, instead of infinity, when the distance between the centers of two magnetic monopoles becomes 0. If we want to apply semi-classical models correctly, we should stick to the rules of classical electromagnetism. That applies even in those cases in which some of the parameters involved are not physically measurable quantities according to Heisemberg's indetermination principle. For example Bohr's and Sommerfeld's method of calculating the frequencies of Hydrogen spectral lines obtains a precision ,rivalling in many cases, that which can be obtained by wave-mechanical methods. This precision is many orders of magnitude better than that one would expect if one should try to estimate the errors in the Bohr and Sommerfeld energy levels on the basis of the errors required by Heisemberg's indetermination principle in some of the parameters involved.

A correct application of semi-classical theory must be done on its own premisses,which means, by ascribing to the magnetic and electric charges their own classical radii and allowing for the lowered magnetostatic and electrostatic fields inside the respective charges.*

The purpose of this paper is to summarize results presented in two earlier papers (Barricelli 1978 A and B) showing that, as far as semi-classical theory is concerned, the difficulties related to the troublesome energy levels of magnetic monopoles

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* Notice that the classical radius of the electron - defined as the distance from centrum where the interaction force with an other elementary charge would be substantially (for ex. 15 %) reduced - is among the quantities whose direct measurement is subject to unacceptable errors (hundreds of times greater than the quantity to be measured), according to Heisemberg's indetermination principle (Barricelli 1978 A, Appendix). Also a direct measurement of the classical radius of the Dirac monopole is subject to substantial, if not quite as fatal, indetermination errors (approaching 10 % of the radius to be measured). In both cases a direct measurement involves a measurement of the angular momentum of a circular orbit with a radius comparable to the classical radius of the particle, which is subject to an error comparable to h. Indirect measurements of the electron radius are subject to the same objections and criticism as, for example, measurements of the angular momenta of electronic orbits based on spectral observations. They would measure a value ascribed to the parameter (analogic parameter) by a semi-classical theory or some other theory, not a true angular momentum. Measurements of the electron radius have given values ranging from 0 to different values approaching the classical radius, depending on the theory (wave-mechanical, classical or semi-classical) used, and they are often based on cross-sections whose relation to the electron radius defined above is questionable at best. Moreover the very fact that the magnetic monopole radius measurement is not quite as sensitive to indetermination principle errors as the electron radius (see above) indicates that inferances about the magnetic monopole radius derived from the measurements of electron radius are not automatically correct.

are artificial ones created by an erroneous application and/or interpretation of semi-classical theory. Of more than forty asymptotically coulombian potential fields tested, fulfilling trivial continuity requirements, and the conditions imposed by a finite radius related to the mass according to classical electromagnetism, none has been found presenting the difficulties discussed in the preceeding section. Difficulties of an other kind have appeared when force fields presenting more than one maximum and minimum have been used. But none of the difficulties we have found appear to be related to excessive interaction forces.

There is no evidence that it is even possible, let alone unavoidable to ascribe to the magnetic monopoles interactions capable of creating the difficulties described above, by using meaningful potential fields consistent with classical electromagnetism. Such difficulties do arise with models treating the magnetic monopoles as point charges*, but not with semi-classical models correctly applied.

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* One may object that the charge of the Dirac monopole has been calculated by Dirac's theory which treats the electric and magnetic charges as point charges. Many results obtained by Dirac's theory as well as by semi-classical theories and other theories are found to be in very good agreement with observations no matter whether they use or fail to use analogical parameters which cannot be measured according to Heisemberg indetermination principle. The question whether Dirac's theory has been successful in the identification of the elementary magnetic charge will ultimately be decided by comparing with experimental observations (such as the masses of elementary particles) the theoretic predictions obtained by using the Dirac monopole as an elementary magnetic charge (see table 4 and section 7).

This misinterpretation and the misunderstandings created by it (see last section) seem to be the main reason why the opportunity to calculate the energy levels of elementary particles by semi-classical methods has been overlooked for more than 10 years, since the earliest magnetic quark models were proposed.

Our belief is that the Bohr and Sommerfeld quantization method still has a role to play in the theory of elementary particles, not less important than the role it has played in the original theory of atomic spectra (see table 4 where the masses of many elementary particles calculated by the Bohr and Sommerfeld method are compared with observed masses).

3. Properties of asymptotically coulombian potential fields obeying classical requirements.

Before describing the magnetic monopoles which have been introduced for the interpretation of elementary particles we shall call attention to some of the main characteristics of the potential fields generated by magnetic monopoles with a mass determined by their magnetostatic energies.

The magnetic monopoles we will deal with are assumed to generate spherically symmetric potential fields which asymptotically approach a coulombian field when the distance r goes to infinity, $r \to \infty$ (asymptatically coulombian fields). There are many asymptatically coulombian fields fulfilling this conditions, and many of them would also have comparable properties within a standard radius r_0 if they fulfill all the requirements (see below) we impose to them. The simplest assumption which is found adequate to interpret the masses of elementary particles is to assume that all magnetic monopole charges have the same standard radius r_0 comparable (see below) to the classical radius of the electron.

A basic property of two equal and opposite magnetic or electric charges with the same finite density distribution assumed to be spherically symmetric* is that they will cancel out if they are placed in the same spot, so that the distance r between their centers is equal to zero. This has a series of implications, such as:

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* Spherical symmetry is not likely in particles with spin different from 0. For the moment we are only presenting examples to illustrate the method.

1. The attraction force between two charges of opposite sign will not go to infinity, but on the contrary it will approach zero when $r \to 0$. The same applies to the repultion force between charges of equal sign.
2. The magnetostatic energy of two equal charges of opposite sign will approach zero when $r \to 0$. As a result the potential energy of the two charges will approach but never exceed the negative sum $-2 M_o c^2$ of their magnetostatic energies which are equal and have been designated by $M_o c^2$, M_o being their selfinduction rest mass.
3. The lower limit of the angular momentum of two interacting charges will be zero instead of a finite number like the angular momentum defined by formula (2). As a result there are no problems with the use of low quantum numbers with a low angular momentum.

All of these conditions are fulfilled by several potential fields presented in the preceeding papers (Barricelli 1978 A and B) including the following one which has been used in the theoretical calculation of the masses of elementary particles[x] and is assumed to give a workable approximation for this pourpose when $R<0.7$.

$$U(r) = \frac{g_1 g_2 + e_1 e_2}{r_o \sqrt{1/(1+R^2) + R^2 \mathrm{Exp}(1/(1+1/SR^2(1-\frac{1}{2}R^2)))}} \tag{5}$$

g_1, g_2 are the magnetic charges, e_1, e_2 the electric charges of two interacting magnetic monopoles, $R=\frac{r}{r_o}$, r being the distance between their centers and r_o their standard radius.

S is a free parameter whose best value (giving the best predictions for the masses of elementary particles including the electron) is found to be $S=5{,}853 \approx \frac{1}{2}\sqrt{137}$. This value of S is suspiciously close the Dirac monopole expressed in units of

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[x]Tis formula gives the potential $U(r)$ only for $r<r_o\sqrt{2}$. The general asymptotic coulombian formula valid for all r values is obtained by substituting the infinite series $\frac{1}{SR^2}(1+\frac{1}{2}R^2+(\frac{1}{2}R^2)^2+(\frac{1}{2}R^2)^3+\ldots)$ for the expression $1/SR^2(1-\frac{1}{2}R^2)$ in formula (5).

$\sqrt{\hbar c}$, namely $\frac{g}{\sqrt{\hbar c}} = \frac{1}{2}\sqrt{137}$ and might not be an accident, even though we do not know what this coincidence means.

The above potential U(R) and the force field generated by it are shown in fig. 1.

According to the above point 2, the rest mass M_o of a Dirac monopole will be $M_o = -\frac{U(O)}{2c^2}$ for the case $g_1 = -g_2 = g$ and $e_1 = e_2 = o$ or:

(6) $$M_o = \frac{g^2}{2r_o c^2}$$

and similarly the rest mass m of an elementary electric charge will be:

(7) $$m = \frac{e^2}{2r_o c^2}$$

If the rest mass of the electron is considered equal to m, the standard radius r_o will be one half of the classical radius r_e of the electron

$$r_o = \frac{r_e}{2}$$

4. Some low energy levels in binary systems.

Examples of energy levels for circular orbits have been presented in a preceeding paper (Barricelli 1978 A). We shall present here an example of energy levels for linear oscillation orbits which have been used in the interpretation of elementary particle masses in a second paper (Barricelli 1978 B).

Linear oscillation orbits are the orbits described by two particles subject to an oscillatory movement on a straight line through their common center of gravity. Both particles move simultaneously through their center of gravity in opposite direction. They reach simultaneously their respective maximum distances from the center of gravity and are pulled back by their reciprocal attraction to repeat in reverse the same movements (Fig. 2).

The main characteristic discriminating oscillation orbits from other orbits is that their orbital angular momentum is equal to zero. They are the only kind of orbits we will need in the low energy levels we are going to deal with, in which the spins of elementary particles seem to be determined exclusively by the spins of the quarks involved. As well known also the version of Bohr's theory of the hydrogen atom, adopted after the introduction of electronic spin, uses in the lowest energy level orbits with angular momentum equal to zero.

The energy levels in linear oscillation orbits can be calculated by the following Sommerfeld integral (see Barricelli 1978 B section 3):

(8) $$\oint P(r_x,r)dr=4\int_0^{r_x} P(r_x,r)dr=nh$$

where n is the integrèr quantum number identifying the energy level, r_x is the maximum distance periodically reached by the two monopoles, $P(r_x,r)$ is defined by the formula

(9) $$P(r_x,r)=M_1 v_1$$

where

(10) $$M_1=\frac{M_{10}^2-M_{20}^2+M^2(r_x,r)}{2M(r_x,r)} \quad ; \quad v_1=c\sqrt{1-M_{10}^2/M_1^2}$$

and

(11) $$M(r_x,r)=\frac{U(r_x)-U(r)}{c^2}+M_{10}+M_{20}$$

M_{10} and M_{20} being the rest masses of the two monopoles.

Using these formulae our machine program can calculate $M(r_x,r)$ for any given r_x and r values by formula (11) then by formula (10) it obtains M_1 and v_1, and $P(r_x,r)$ is then given by formula (9). An r_x value fulfilling formula (8) can then be obtained by successive approximations. Once r_x is determined, the bindings energy E, and the mass M of the two-body system is given by

(12) $$E=U(r_x) \quad ; \quad M = M_1 + M_2 + \frac{E}{c^2}$$

Table 1A

Masses of binary systems of magnetic monopoles with respective rest masses M_{10}, M_{20} and the respective magnetic charges g_1, g_2 (g being the Dirac monopole, and $M_o = \frac{g^2}{2r_o}$ the monopolar unit of mass).

		M_{20} / g_2	Energy level n=1: M_o, $-g$	Energy level n=1: $4M_o$, $-2g$	Energy level n=1: $9M_o$, $-3g$	Energy level n=2: M_o, $-g$	Energy level n=2: $4M_o$, $-2g$	Energy level n=2: $9M_o$, $-3g$
M_{10}	g_1							
M_o	g		0.08307	1.07937	4.08467	0.19111	1.18723	4.20033
$4M_o$	$2g$		1.07937	0.05675	1.05279	1.18723	0.13884	1.12998
$9M_o$	$3g$		4.08467	1.05279	0.04416	4.20033	1.12998	0.10952

Table 1B

Maximum reciprocal distance (r_o=1) reached by the two monopoles in their linear oscillations.

		M_{20} / g_2	Energy level n=1: M_o, $-g$	Energy level n=1: $4M_o$, $-2g$	Energy level n=1: $9M_o$, $-3g$	Energy level n=2: M_o, $-g$	Energy level n=2: $4M_o$, $-2g$	Energy level n=2: $9M_o$, $-2g$
M_{10}	g_1							
M_o	g		0.36882	0.29541	0.26802	0.48906	0.38309	0.34473
$4M_o$	$2g$		0.29541	0.22168	0.19500	0.38309	0.28423	0.24893
$9M_o$	$3g$		0.26802	0.19500	0.16717	0.34473	0.24893	0.21268

Table 1C

Maximum velocities v_1/c , v_2/c of the two monopoles (c being the speed of light).

		M_{20} / g_2	Energy level n=1: M_o, $-g$	Energy level n=1: $4M_o$, $-2g$	Energy level n=1: $9M_o$, $-3g$	Energy level n=2: M_o, $-g$	Energy level n=2: $4M_o$, $-2g$	Energy level n=2: $9M_o$, $-3g$
M_{10}	g_1							
M_o	g	v_1/c	0.27955	0.33946	0.36895	0.40842	0.49080	0.52941
		v_2/c	0.27955	0.08986	0.04407	0.40842	0.13946	0.06917
$4M_o$	$2g$	v_1/c	0.08986	0.11848	0.13418	0.13943	0.18392	0.20833
		v_2/c	0.33946	0.11848	0.06007	0.49080	0.18392	0.09425
$9M_o$	$3g$	v_1/c	0.04407	0.06007	0.06991	0.06917	0.09425	0.10981
		v_2/c	0.36895	0.13418	0.06991	0.52941	0.20833	0.10981

This way all of the parameters: maximum distance r_x, velocities v_1 and v_2, mass of the system M are obtained.

Table 1A shows for two energy levels n=1 and n=2 the masses (energies) of two-body systems with magnetic charges g_1=g, 2g, 3g in the first body combined with the charges g_2=-g,-2g,-3g in the second body. The rest masses of the two bodies are assumed to be equal to their respective self-induction masses (or magnetostatic energies divided by c^2). All masses are given by using M_o (formula 6) as a unit of mass. Table 1B gives the maximum distances r_x between the two bodies and Table 1C their maximum respective velocities v_1 and v_2 for the same energy levels n=1 and n=2.

The same program used in order to calculate this tables is also used for the calculation of the masses of elementary particles. Similar tables for circular orbits using different potential functions have been presented earlier (Barricelli 1978 A).

The very fact that it has been possible to calculate these energy levels without running into imaginary or complex solutions is evidence that the strong magnetic forces between monopoles do not have to represent a basic difficulty in a selfconsistent semiclassical approach.

5. Magnetic monopoles involved in the integer charge model.

The model of elementary particles we are going to present uses some of the basic ideas adopted by the quark models with, however, substantial modifications designed to achieve the following aims:

(1) Interpret the forces which keep the magnetic monopoles in an elementary particle together as magnetic forces.

(2) Give an interpretation of the masses of elementary particles, and a means to calculate these theoretically.

(3) Give a simple interpretation of the decays of elementary particles.

(4) Interpret the leptons as a class of particles formed by the same basic monopoles by which the other particles are formed, and apply this interpretation as a means to calculate the masses of leptons by the same procedure adopted in the calculation of the masses of hadrons.

We shall start by presenting the modifications introduced in the quark models in order to achieve these objectives.

The quarks are ascribed positive magnetic charges equal to the Dirac monopole g , in addition to their electric charges, and are respectively designated by the symbols U_1 (u-quark), D_1 (d-quark), S_1 (s-quark) and C_1 (c-quark). The low index 1 identifies the number of positive magnetic charge units. The corresponding anti-quarks are designated by the symbols U^1, D^1, S^1, C^1, upper indexes designating the number of negative magnetic charge units. A new particle designated as Baric and identified by the symbol B^3, a boson of spin 0, is ascribed three negative magnetic charge units. Its anti-particle is designated by the symbol B_3 and is ascribed 3 positive magnetic charge units. A baric is assumed to be present in each baryon, and its triple negative magnetic charge is assumed to keep the three positively charged quarks together, in the same way as the triple charge of a Litium atomic nucleus keeps three electrons together.*

The introduction of an extra boson, the baric, in each baryon makes the assumption of fractional electric charges ($-\frac{1}{3}$ and $\frac{2}{3}$) ascribed to the three quarks unnecessary. If we assign a negative electric charge - 1 to the baric and add a positive electric charge $\frac{1}{3}$ to each quark, the electric charges

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* A similar idea was proposed by Schwinger (1969), but his hypothesis that the triply charged boson would be successively absorbed by the three quarks, is not confirmed by our investigation, as far as the barijons are concerned.

of the baryon will remain the same, whereas the quarks will obtain integer electric charges, namely +1 for the u and c-quarks and 0 for the d and s-quarks (see table 2). What is more important is that this model ascribing to the quarks integer electric charges (integer charge model) has the advantage that it makes possible an interpretation of the leptons by the same basic monopoles used in the interpretation of hadrons (see section 8). The usual fractional charge model does not seem apt to give a similar interpretation of the leptons without ascribing to the leptons the same kind of fractional ($\frac{1}{3}$ and $\frac{2}{3}$) electric charges which are ascribed to the quarks.

The baric and the quarks are not the only magnetic monopoles we are going to deal with. Other magnetic monopoles can be constructed by a type of association between two or

Table 2

Magnetic monopoles involved as constituents of elementary particles according to the interger charge interpretation.*

Name	Symbol	Magnetic charge	Electric charge	Spin	Strangeness	Charm
Baric	B^3	-3	-1	0	0	0
u-quark	U_1	1	1	1/2	0	0
d-quark	D_1	1	0	1/2	0	0
s-quark	S_1	1	0	1/2	-1	0
c-quark	C_1	1	1	1/2	0	1

* The respective antiparticles B_3 , U^1, D^1, S^1, C^1 have opposite magnetic and electric charges, and opposit strangeness and charm. Lower indexes identify positive magnetic charges; upper indexes identify negative ones.

more monopoles which we will call "level zero" or (L-0)associations.* An (L-0) association is a monopole whose spin, electric and magnetic charges are respectively the sum of the spins, electric and magnetic charges of the associated monopoles. For example the (L-0) association of the baric B^3 with a U_1 will be a monopole designated by the symbol $(B^3U_1)_o$, hereafter also called F^2, with spin $0+\frac{1}{2} = \frac{1}{2}$, magnetic charge $-3g+g=-2g$ and electric charge $-e+e=0$. Its anti particle F_2 is called "heavy fermion" (see table 3).

The mass of an (L-0) association is calculated on the basis of its magnetostatic and electrostatic energy by the same rules applied for a single monopole (see next section).

In a semi-classical model an (L-0) association can be interpreted as a system of particles at the lowest possible energy level (n=0) where n is the quantum number in the Sommerfeld formula (8). This energy level is characterized by associated particles at rest in the position of lowest energy, the baricenter of the system.

Other (L-0) associations will be introduced subsequently. We may, however, give notice that the (L-0) association of a monopole and its antiparticle such as $(U^1U_1)_o$, $(B^3B_3)_o$ or $(F^2F_2)_o$ is considered equivalent to annihilation. This kind of (L-0) associations are not real particles. Moreover, the (L-0) association of a monopole, such as B^3 with an other (L-0) association such as $F_2=(B_3U^1)_o$ including its antiparticle is considered equivalent to the result obtained by removing (annihilating) the two monopoles (B^3 and B_3) from the association.

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* Associations with similar charge and spin characteristics were introduced by Schwinger, who assumed that a quark for example U_1, could absorb a boson, for example B^3, to form a particle, say F^2, with charges and spin obtained by adding together those of the two particles.

$$(B^3F_2)_o=(B^3B_3U^1)_o\dot{=}U^1$$

An other monopole, a boson of spin 0, magnetic charge - g and electrically uncharged, called "light boson" and designated by the symbol L (see table 3) was originally introduced as a means to interpret the properties of the strange quark (see next section).

The three monopoles B^3, U_1, L^1 are the basic monopoles from which all other particles will be constructed by (L-O) and higher energy associations.

6. Masses of quarks and basic monopoles.

Formulas (6) and (7) give respectively the masses of an elementary magnetic charge g with a standard radius r_o and an elementary electric charge e with the same standard radius. By the same argument a magnetic charge ng with standard radius r_o will have the mass M given by

(13) $$M=\frac{(ng)^2}{2r_oc^2}=n^2M_o$$

M_o being the mass of a Dirac monopole, hereafter designated as the "monopolar unit" of mass.

The masses of quarks and magnetic monopoles we are going to use are given in table 3. Electrically charged particles (such as the u-quark and the baric) have in addition to their magnetostatic mass also an electrostatic mass M_e defined by

(14) $$M_e=\frac{e^2}{2r_ec^2}=0.0002130M_o$$

see formula (1).

Two of the quarks, listed in table 3, namely the s-quark and the c-quark, are ascribed masses greater than the values one would obtain by applying the formulae (13) and (14). It was soon found that in order to interpret the masses of strange and charmed particles it would be necessary to ascribe to these two quarks masses greater than their magnetostatic and electrostatic self-

Table 3

Description of monopoles used (for split S and C quarks, see section 8).

Particle name	Symbol	Mass monopolar U.	Electric charge	Magnetic charge	Spin	Definition brief notat.
Baric	B^3	9.000213	-1	-3	0	B
Light boson	L^1	1.000000	0	-1	0	L
u-quark	U_1	1.000213	1	1	1/2	U
Heavy fermion	F_2	4.000000	0	2	1/2	(BU)0
d-quark	D_1	1.000000	0	1	1/2	(FL)0
s-quark (compact)	S_1	1.079375	0	1	1/2	(FL)1
s-quark (split-T)	T_1	1.070569	0	1	1/2	--
s-quark (split-Q)	Q_1	1.062369	0	1	1/2	--
c-quark (compact)	C_1	1.572588	1	1	1/2	((BS)2L)3
c-quark (intern-Q)	I_1	1.557265	1	1	1/2	((BQ)2L)3
c-quark (split-A)	A_1	1.544368	1	1	1/2	--

induction masses calculated by these formulas, and approaching for many elementary particles (see next section) the values indicated in table 3. This led to an interesting discovery. It was found that the mass to be ascribed to the s-quark would have to be close to the mass of a system formed by an association at the energy level 1 of two monopoles with the respective magnetic charges -g and +2g, which is given in table 1A. It was in fact so close that we have been able to adopt this mass for the strange quark in table 3. This led to the hypothesis which is supported by additional evidence partly presented in sector 8 and 9, that the s-quark is not a single monopole, but a system of two monopoles of magnetic charges 2g and -g respectively, associated at the energy level 1. Such a system will be called "level 1" or shortly (L-1) association. One of the two monopoles in this (L-1) association would have to be a fermion, the other one a boson.

The simplest solution of this problem was found by introducing a light boson L^1 of magnetic charge -g, no electric charge and no spin (see table 3). The (L-1) association hereafter designated as $(F_2L^1)_1$ or shortly (FL)1, of this boson with the heavy fermion F_2 will be considered equivalent to the strange quark S,

$$S_1=(F_2L^1)_1, \text{ or shortly } S=(FL)1$$

The (L-0) association between the same monopoles, namely $(F_2L^1)_0$ or shortly (FL)0 has the same mass, the same charges and the same spin as the d-quark, and is used as an interpretation of this quark (see table 3):

$$D_1=(F_2L^1)_0 \text{ or shortly } D=(FL)0$$

The light boson L has been used in the interpretation of many elementary particles including leptons and other particles not involving the s and d-quarks.

The mass of the c-quark was interpreted by ascribing to this quark a more elaborate composition indicated in table 3, where $(B_3S^1)_2$, shortly (BS)2, stands for an energy level 2 or (L-2) association of an anti-baric B_3 with an s-antiquark S^1 and $((B_3S^1)_2L_1)_3$, shortly ((BS)2L)3 stands for an (L-3) association of (BS)2 with L:

$$C=((BS)2L)3$$

The short notations such as (BU)0,(FL)0, (FL)1 and ((BS)2L)3 make no distinction between a particle and its antiparticle, but they lead to no other ambiguities.

The interpretation of the c, s and d quarks in terms of the basic monopoles B, U and L as well as the interpretations of all other particles listed in the tables are tested by verifying the conservation of the basic monopoles in particle decays (see section 9).

7. The interpretations of elementary particles and their masses.

The calculation of the masses of elementary particles as well as the masses of the s and c-quarks is made with the same two-body program which has been used for the calculation of the masses of two-body systems listed in table 1. The use of a two-body formula or program for the solution of three-body or more-body problems can, of course, never give precise results, and methods to estimate roughly approximate corrections in several cases in which the errors are unacceptably large will be given in section 8 (see split s-quark and split c-quark). Nevertheless two-body formulas have been used by Niels Bohr and others for the solution of multibody problems, for example in the calculation of the energy levels of the uttermost electron of atoms with a single electron in the outer orbit.

Our model for the interpretation of baryons with a triply charged (-3g) boson B^3 and three fermions, each one with a single opposite magnetic charge (+g) is the first example of a 4-body problem we will have to handle with our program. As well known fermions are subject to severe restrictions imposed by Pouli's exclusion principle and other restrictions. For example one can not include more than two fermions in the lowest energy level about the baric (just as one can not place more than two electrons in the lowest energy level about a Litium atom). Moreover the two fermions must have opposite (anti-parallel)spins and (an additional restriction which do not apply for atoms) they must be two different quarks, and none of them can be an s or c-quark. In other words they can only be a u-quark and a d-quark. The last additional restrictions concerning the nature of the quarks admitted in the lowest energy level might be related to the more intimate (positional) association between the two quarks compared with the two electrons in the lowest energy level of an atom. In fact the oscillatory movements in the linear oscillation orbits involving a baric and two quarks are believed to keep the quarks together all the time in a "positional association" in which their centers coincide.* This gives a

* Other linear oscillation movements might lead to a greater ratio between total energy and momentum, meaning to a system with greater energy, since the momentum is fixed by the Sommerfeld condition (formula 8).

possibility of treating this kind of three-body system as a two-body system in which the two quarks are treated as a single body with twice their magnetic charge and nearly four times their mass.

Concerning the energy levels of such a system a curious observation has been made, establishing a drastic difference between fermions and bosons in this sort of positional associations. If the two positionally associated monopoles are fermions (for example quarks) the momentum in the Sommerfeld condition (formula 8) is never lower than 4h, and the lowest possible energy level in this sort of system is therefore n=4. Thus the (L-4) association $(B^3U_1D_1)_4$ or shortly (BUD)4 has the lowest energy level we can ascribe to the association of one baric with two quarks. This is twice as much momentum as the lowest momentum admitted for the two lowest energy electrons in one atom which is 2h (1h for each electron). The reason is perhaps related to the fact that the positional association of the two fermions gives them a twice as high mass(say $4M_o$ instead of $2M_o$ as the sum of their individual masses would be). Whatever the reason, this rule does not, however, apply if one or both of the positionally associated magnetic monopoles is a boson. In this case the two associated magnetic monopoles can be treated as a single monopole also with respect to the selection of energy levels. In table 4 we will find several examples of positional associations of one boson with only one fermion, in which the energy level is 1 or even 0 if no more than one fermion is involved in the system.

The mass of the (L-4) association (BUD)4 can be calculated as the mass of a two body system at the energy level 4 formed by a baric B (of magnetic charge -3g, electric charge -e and mass 9.000213 M_o, see table 3) and the association UD (of magnetic charge 2g, electric charge e and mass 4.000213 M_o). The result is a particle (BUD)4 with a magnetic charge -g, electric charge 0, mass 1.3145541 M_o, and spin 0, since the two quarks U and D have opposite spins. The mass is calculated by the same machine program used in the calculation of the masses in table 1A.

In order to calculate the masses of the lowest energy baryons we will now have to include an extra quark in the system, which will have to be put in an other (external) energy level. Following the methods used in atomic theory (for atoms such as Litium, Natrium etc. with a single electron in the outer orbit) we can do that by treating the external quark and the rest of the system, namely (BUD)4, as two bodies in a two body system. The lowest permitted energy level is in this case 1, and the mass of the resulting (L-1) association calculated by the same program used in table 1 will respectively be for the 4 possible selections of the external quark:

External quark	Configuration	Mass monopolar U.	Baryon interpretation
U	((BUD)4U)1	0.391586	P(938) (Proton)
D	((BUD)4D)1	0.391379	N(939) (Neutron)
S	((BUD)4S)1	0.468788	Λ(1115)
C	((BUD)4C)1	0.953764	Λ_c(2260)

This is the way the theoretically predicted masses of the baryons listed in table 4 are calculated. When the three quarks do not include a U and a D, the above type of configuration can not be used, and must be substituted by a configuration, such as for example Σ^+=((BU)1 US)4 (see table 4) in which only one quark is allowed in an internal (L-1) association system (BU)1 which can be associated with the two quarks U and S in the (L-4) system ((BU)1 US)4. In this case an s-quark is permitted in the (L-4) level; but also in this case the two quarks in the (L-4) level must be different ones. This restriction does not apply, however, if we go to a higher energy level, for ex. (L-5). At this level two identical quarks are permitted in the external level, as for example in the two particles Δ^{++}=((BU)1 UU)5 and Δ^-=((BD)1DD)5 (see table 4).

In the (L-4) associations of table 4 the two quarks at the (L-4) level must have opposite spins. As a result the

Table 4

Configurations defining elementary particles and derived properties. The million electron volt (MeV) masses are the products of the (monopolar U.) masses by the factor 0.511/ 0.000213, where 0.511 is the MeV mass of the Electron, and 0.000213 its monopolar U. mass (formula 14).

Particle name	Symbol (+obs. mass)	Theoretic calc. mass MeV	Monopolar U.	Elctr. charge	Spin	Configuration
Proton	P(938)	939.439	0.391586	1	1/2	((BDU)4U)1
Neutron	N(949)	938.942	0.391379	0	1/2	((BDU)4D)1
Lambda	Λ(1115)	1124.651	0.468788	0	1/2	((BDU)4S)1
Sigma -	Σ^-(1197)	1181.492	0.492482	-1	1/2	((BD)1DS)4
Sigma 0	Σ^0(1192)	1180.977	0.492267	0	1/2	((BU)1DS)4
Sigma +	Σ^+(1189)	1181.476	0.492474	1	1/2	((BU)1US)4
Delta -	Δ^-(1232)	1245.304	0.519080	-1	3/2	((BD)1DD)5
Pi 0	π^0(135)	136.143	0.056749	0	0	(FF)1
Pi ±	$\pi^\pm$(140)	136.652	0.056960	±1	0	(FUL)1
Ro 0	ρ^0(770)	771.325	0.321511	0	1	(((BD)1B)1D)1
Lambda C	Λ_c(2260)	2288.139	0.953764	1	1/2	((BDU)4C)1
Psi	ψ(3097)	3099.973	1.292161	0	1	(CC)2
D 0	D^0(1863)	1864.123	0.777022	0	0	((BC)1(BU)1)1
D ±	$D^\pm$(1868)	1864.650	0.777242	±1	0	((BC)1(BD)1)1
F ±	$F^\pm$(2040)	2045.925	0.852802	±1	0	((BC)1(BS)1)1
e-neutrino	ν_e(0)	0.000	0	0	1/2	(FLL)0
mu-neutrino	ν_μ(0)	0.000	0	0	1/2	(BULL)0
Electron	$e^\pm$(0.511)	0.511	0.000213	±1	1/2	(UL)0
Muon	$\mu^\pm$(105)	106.435	0.044365	±1	1/2	(BFL)1
Tau	$\tau^\pm$(1807)	1809.968	0.754449	±1	1/2	(B(BL)OC)3

baryons involving (L-4) associations can only have spin $\frac{1}{2}$, since oscillation orbits have no ongular momentum. This condition is not required for the two quarks in an (L-5) orbit which can have parallel spins. As a result the baryon involving an (L-5) association can have spin $\frac{3}{2}$. As a matter of fact we find a spin $\frac{3}{2}$ in all baryons involving (L-5) associations. We do not know the reason for this. A possible explanation might be that two quarks with opposite spins are unlikely to stop at the higher (L-5) energy level during the formation of a baryon, and would immediately drop to the lowest possible (L-4) energy level. The same phenomenon is observed in mesons, where higher energy levels giving the possibility of parallel spins resulting for example in a particle with spin equal to 1, are seldom if ever found in particles with the spin 0, characteristic for the association of fermions with opposite spins. Also in this case we may suggest that, during the formation of a meson, fermions with opposite spins are not likely to stop at a higher energy level, and will usually proceed to the lowest energy level permitted for such spins.

This explains how the masses and spins of the baryons in table 4 are calculated by the semi-classical model we are using.

The way in which the masses and spins of the other particles, defined by their configurations presented in table 4 and 3 are calculated, is now selfexplanatory. Starting with the c-quark whose configuration ((BS)2L)3 is given in table 3, in order to calculate its mass one calculates first the mass of the (L-2) association (BS)2, then the mass of its (L-3) association ((BS)2L)3 with the light bosen L. By the usual procedure this gives the mass 1.5725878 M_0 indicated in table 3. The spin is of course 1/2 since S is the only fermion present in its structure. Its magnetic charge will be g and its electric charge e, as indicated by its configuration. It is clear that a particle so massive and complex will hardly behave quite the same way as the other quarks (see below).

Several mesons and leptons are presented in table 4. The distinction between baryons, mesons and leptons is that baryons contain 3 fermions, mesons 2 fermions and leptons only one fermion in their structure.

Since leptons have only one fermion, (L-0) associations are permitted for this kind of particles. Indeed we find three leptons which are interpreted as (L-0) associations in table 4, namely the electron $e^{\pm}$=(UL)0 and the two neutrinoes ν_e =(FLL)0 and ν_μ=(BULL)0. Since F=(BU)0 according to its definition (table 3) one may wonder what is the difference between the two neutrinoes. In order to explain decay processes, particularly those involving neutrinoes, it is necessary to assume that the structure (BU)0 is sufficiently stable to survive, at least temporarily, even in (L-0) association with other monopoles. According to this interpretation the structure ((BU)0LL)0 is not equivalent to (BULL)0 as long as the two monopoles B and U stick together (Barricelli 1978B)

The τ lepton is interpreted as an (L-3) association (B(BL)0C)3, involving the charmed quark C. Since the charmed quark is it self on (L-3) association (see table 3) it is no surprise that its association with other monopoles may often be a relatively high level association. The existence of a "charmed lepton" involving the charmed quark may suggest that also a "strange lepton" in which the charmed quark is replaced by a strange quark might exist. This would be a neutral lepton whose expected mass and other properties are described by Barricelli (1979).

The interpretation of meson masses is obtained by assuming that many of them are not just quark-antiquark associations (as conventional quark models assume) but rather associations of monopoles involving two magnetic charges instead of one. Associations of two monopoles with a single magnetic charge each have much greater mass and energy, and are expected to be more unstable. For example the (L-1) associations (UU)1, (DD)1 and (UD)1 would have masses around 198 to 199 M.E.V. instead of the masses around 135 to 136 M.E.V. which are characteristic for the (L-1) associations (FF)1 and (FUL)1, more in line with the masses of Π mesons. The only cases of quark - antiquark associations we have found are of the type (SS)1, (SS)2, (SS)3, (CC)1 and (CC)2, most of them involving, however, splitted s or c-quarks (see next section).

In the present approximate model we have adopted, the only electrical interactions we have taken into account are those between two electric charges. We have ignored the interactions between electric charges and the electric dipol moments of the involved fermions. As a result the contribution of electric charges to the masses of particles are subject to very substantial errors. For example the neutral particle in each group, Neutron, Δ^o, Σ^o etc. are always ascribed the lowest predicted masses, contrary to the observation that the baryon with a single positive charge, Proten, Δ^+, Σ^+ etc. is the one with the lowest mass in its group.

8. The split s and c quarks.

Our methods of treating three-body problems, four-body problems etc. as two-body problems has its limitations, and can not be expected to give always the good fit we observe in table 4. The first condition for their applicability is that the configurations by which the various particles are described reflect some reality concerning the way in which the various monopoles participating in the building of each elementary particle are put together. But even if they do to some extent, there are many possibilities for deviations from the rigid schemes defined by the assumed configurations of the various particles leading, for example, to different orbits and different associations for a part of the time. There is no way, short of a separate treatment of the multibody problems involved in each particle, to obtain precise solutions. More or less successful approximations can, however, be obtained by empirical rules derived in part from observation and in part from an estimate of the kind of deviations one may expect in the various types of particles.

The deviations from expected (configurational) masses may occur where the complexity and energy level of the system make it possible to find orbits with the same set of quantum numbers (or momentums) which have a lower energy and are therefore more stable than the strictly configurational ones. We may therefore expect to find deviations leading to masses lower than the configurational ones.

We are going to describe a couple of empirical corrections related to the s-quark (S-corrections) and similar corrections related to the c-quark (C-corrections). Both of these quarks are formed by more than one magnetic monopole associated at an energy level higher than (L-0). There are two corrections of which one or the other is often associated with particles containing an s-quark. One of the corrections, often associated with mesons, can be applied by ascribing to the quark a mass 1.0705687 M_o lower than the configurational mass given in table 3. This means that in the calculation of meson masses we often replace the s-quark with a "split-T" quark designated by the symbol T_1 (see table 3) which has a lower mass but otherwise the same properties as the s-quark. Likewise in the calculation of the masses of several baryons we may replace the s-quark with a "split-Q" quark designated by the symbol Q_1 (see table 3) which has a still lower mass 1.0623688 M_o but otherwise the same properties as the s-quark.

The masses of these split quarks were calculated by splitting S_1 into its two components, the F_2 and L^1 monopoles, which were then associated one at a time to an other particle, for example (BUD)4. We calculated this way the mass of the configuration (((BUD)4F)1L)1 and substracted this mass from that of the configuration ((BUD)4S)1 which is the Λ(1115) baryon. This difference was then substracted from the mass of S, in order to calculate the mass of T(see Barricalli 1978 B). Similar procedures using a configuration in which S is contained at a higher energy level, for example (L-5) instead of (L-1), give larger differences.

These considerations have only the purpose of showing that the deviations from strict configurational masses are not inconsistent with the differences one might expect for comparable sets of energy levels and also as a practical way of estimating the expected deviations. They should not be interpreted as an attempt to describe the actual orbital deviations.

Similar procedures are used for the c-quark in order to calculate the mass of the "split A" quark A_1 (see table 3). The "intern Q" quark I, is obtained by substituting Q for S in the definition of C (table 3).

Particles whose masses are calculated by using split s and c quarks are listed in table 5.

Table 5

Properties of elementary particles involving split (S and C) quarks.

Particle name	Symbol (+obs. mass)	Theoretic calc. mass MeV	Monopolar U.	Elctr. charge	Spin	Configuration
Xi -	Ξ^-(1321)	1319.412	0.549970	-1	1/2	((BS)1DQ)4
Sigma -	Σ^-(1385)	1390.117	0.579442	-1	3/2	((BD)1DQ)5
Xi -	Ξ^-(1530)	1535.053	0.639856	-1	3/2	((BD)1QQ)5
Omega -	Ω^-(1672)	1673.594	0.697604	-1	3/2	((BQ)1QQ)5
Eta	η(549)	550.441	0.229440	0	0	(ST)1
Eta'	η'(958)	962.268	0.401102	0	0	((BL)OUT)4
Omega	ω(783)	779.892	0.325082	0	1	(TT)2
Phi	ϕ(1020)	1038.133	0.432725	0	1	(TT)3
D' 0	D'^0(2006)	2015.529	0.840132	0	1	((BI)1(BU)1)2
D' ±	$D'^{\pm}$(2009)	2016.053	0.840351	±1	1	((BI)1(BD)1)2
F' ±	$F'^{\pm}$(2140)	2157.510	0.899314	±1	1	((BI)1(BQ)1)2

Table 6

Configurations of elementary particles.

B A R Y O N S

Strangeness	Name	Octet of spin 1/2 Configurations		Name	Decaplet of spin 3/2 Configurations		
-3				Ω(1672)	((BQ)1QQ)5		
-2	Ξ(1321)	((BS)1DQ)4	((BS)1UQ)4	Ξ(1530)	((BD)1QQ)5	((BU)1QQ)5	
-1	Σ(1190)	((BD)1DS)4	((BD)1US)4 etc.	Σ(1385)	((BD)1DQ)5	((BD)1UQ)5	((BU)1UQ)5
0	N,P(938)	((BUD)4D)1	((BUD)4U)1	Δ(1232)	((BD)1DD)5	((BD)1UD)5	((BU)1UD)5 etc
-1	Λ(1115)	((BUD)4S)1					

M E S O N S

	Name	Nonet of spin 0		Name	Nonet of spin 1
0	η'(958)	((BL)OUT)4?		Φ(1020)	(TT)3
0	η(549)	(ST)1		ω(783)	(TT)2
±1	K^{-+}(494)	((BT)1F)1		K^{-+}(886)	((BT)1(BU)1)2
±1	K° (498)	((BT)1UL)1	((BU)1TL)1	K° (892)	((BT)1(BD)1)2
0	π^{-+}(140)	(FUL)1		ρ^{-+}(765)	(((BD)1B)1U)2
0	π° (135)	(FF)1		ρ° (770)	(((BD)1B)1D)2

	Name	Charmed triplet of spin 0	Name	Charmed triplet of spin 1
0	D° (1863)	((BC)1(BU)1)1	D'° (2006)	((BI)1(BU)1)2
0	D^{-+}(1868)	((BC)1(BD)1)1	D'^{-+}(2009)	((BL)1(BD)1)2
±1	F^{-+}(2040)	((BC)1(BS)1)1	F'^{-+}(2140)	((BI)1(BQ)1)2

	Name	Doubly charmed of spin 0	Name	Doubly charmed of spin 1
0	η_c(2830)	(AC)1	Ψ(3095)	(CC)2

L E P T O N S

Name	Configuration	El. charge	Strangeness	Charm
τ^{-+}(1807)	(B(BL)OC)3	±1	0	±1
S_o(450?)	(B(BL)OS)2 or (B(BL)OS)1	0	±1	0
μ^{-+}(106)	(B(BL)OU)1 or (BFL)1	±1	0	0
e^{-+}(0.511)	(UL)O	±1	0	0
ν_e(0)	(DL)O or (FLL)O	0	0	0
ν_μ(0)	(BULL)O	0	0	0

In table 6 the configurations of some of the most common baryons , mesons and leptons are presented in a way which may facilitate comparisons.

The introduction of the split quarks is equivalent to the introduction of 4 free parameters, namely the masses of split-T, split-Q, intern-Q and split-A. Each one of these parameters is, however, used as a common correction for a well defined class of elementary particles (see tables 5 and 6). However, even if one takes the attitude that this preliminary attempt to find empirical rules for the calculation of the masses of deviant particles is premature, there are more than enough particles in table 4 whose masses are calculated with errors mostly lower than 1 %. To our knowledge no other theory has been successful in calculating, on a purely theoretical basis, the masses of so many elementary particles. The only physical parameter introduced in our machine program (a simple 3 page fortran program) is the fine structure constant 1/137.036, when the units of mass, length and time are selected by putting $c=1$, $\hbar=1$ and $r_0=1$, r_0 being the semi-classical radius of the electron. By this simple program we have calculated the masses of all the particles listed in table 4, simply by assigning in the input the configurations of the respective particles. By including in the input the 4 masses of the split quarks we were also able to calculate the masses of the particles in table 5.

9. The B, U, L conservation law.

In a preceeding paper (Barricelli 1978 B section 12) the decay processes and the respective decay products, of the particles listed in table 4 and 5, are interpreted on the assumption that the three basic monopoles B, U and L are conserved in every decay. According to this assumption the only objects which can be created or destroied during a decay process are pairs formed by a basic monopole or an (L-O) association, and its anti-

particle, namely*:
B^3B_3, U^1U_1,L^1L_1, F^2F_2, D^1D_1, e^+e^-, $\nu^e\nu_e$, $\nu^\mu\nu_\mu$. All the decay products are assumed to be formed by rearrangements (reassociations) of the basic monopoles left after such pair creations and/or annihilations.

By making use of this B,U,L conservation law we were able to interpret all but two of the decays of the particles listed in table 4 and 5, published by "Particle Properties" (April 1974 & April 1978). The two recalcitrant decays were: $K^+(494)\rightarrow\Pi^-e^+e^+$and $K^+(494)\rightarrow\Pi^-\mu^+e^+$. However these two decays are obviously erroneous, since the formation of two positively charged leptons by a meson decay requires the formation of two neutrinoes or some other leptons. We have interpreted these two decays after adding the missing neutrinoes (see Barricelli 1978 B).

Together with the theoretic calculation of masses, the interpretation of decay processes has been an important tool in the process of identifying or verifying the configurations ascribed to the various elementary particles.

10. The prejudice about magnetic monopole forces and its effects on progress.

The misconception about the semi-classical treatment of magnetic monopole forces, which is discussed at the beginning of this paper, has created and is still creating serious hindrances to progress in this area of research. Despite the results presented in this paper and the preceeding ones, it is almost impossible to make many people realize the mistake. A couple of referee comments may help explaining this point:

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* All but the first three pairs are actually redundant, since for example the formation or annihilation of the pair F^2F_2 can be replaced by the formation or annihilation of the two pairs B^3B_2 and U^1U_1, and similar substitutions are possible for the other pairs of (L-O) associations. The interpretation of a decay process is, however, in many cases simplified by allowing for (L-O) association pairs.

These papers show praiseworthy efforts to create new ideas, but the methods employed are quite inadequate for the purpose.

(i) Extremely strong magnetic fields are involved, and these will produce large currents in the vacuum, and these currents then interact in such a way as to modify strongly the original fields.

(ii) The dynamics of such magnetic quark systems cannot be treated by Bohr-Sommerfeld quantization, nor can it be treated by Dirac's formula for H-like atoms. One must use some quantum field theory method which makes it possible to include all the large quantum field effects. Anything less is hopeless.

If the referee had read the papers, or even paid attention to their titles, he could not have avoided noticing that one of the papers contains a refutation of his argument as far as Bohr-Sommerfeld quantization is concerned. Neither has he explained "by what miraculous accident" the theory presented in these papers is capable of predicting the masses of elementary particles (see table 4), in spite of the referee's argument about the strong magnetic fields and the currents in the vacuum. The magnetic fields are exceedingly strong only for people who ignore the classical radius of the magnetic monopoles and its effect on the strength of the magnetic field according to semi-classical theory (see section 2).

The first thing a would be referee should learn, is that a theory cannot be disproved just by quoting another theory. Only experimental facts can disprove a theory, and those are not easy to get at without reading the papers one is supposed to review.

An other reviewer masterpiece, this time in connection with a summary paper which was sent together with the two papers (Barricelli 1978 A and B):

Author Nils Aall Barricelli
Title A summary of Results Obtained by Magnetic Quark Models

> It is totally ununderstandable what the author intends to prove, except for the vague assertion that if quarks are magnetic monopoles their mass might be the magnetostatic energy and their interaction energy might be the magnetic interaction energy.

Perhaps the referee did not realize that the masses of elementary particles listed in the tables were calculated by a machine program based on the "vague assertion" he quotes. He may have believed that those masses were experimental ones copied from some text book, if he has noticed them at all.

Most mathematics or physics students at this university, and I imagine in other universities as well, are capable of reading those papers and understanding some of the main points. Quite a few of them are also capable of writing the data machine programs needed in order to calculate the masses of elementary particles. The simple (2 or 3 page) machine programs used in these papers are partly or entirely written by students.

I think I would subscribe to Max Plank's view that it is useless to try convincing experts about new ideas. The only alternative is to wait till they die and are replaced by new people. In this case it is not even new ideas. It is just the oldfashioned Niels Bohr's idea applied to a new field.

Apart from the referee reports, the responses we have received to the limited preprint edition of these papers, are positive.

W A R N I N G

Many inferences from recent experimental results have been obtained by wave mechanical or related approaches, but are not found to be derivable by semi-classical methods. Quite a few of them, designed to obtain informatiom about quarks and other partons, including the identification of their properties and various parameters involved, could be used as arguments against the magnetic quark model presented in this paper.

In order to be relevant for a semi-classical model, such as the magnetic quark model, every inference must be obtainable also by semi-classical arguments and not only by wave mechanical or related argumemts. For example wave mechanical interpretations of recent experiments designed to estimate an upper limit of the electron radius are not applicable to semi-classical models unless they are confirmed by semi-classical arguments. The same applies to wave mechanical estimates of the electric dipole moment of neutrons etc. Semi-classical theories must be built on semi-classical premisses and interpretations, not on wave mechanical ones.

The best way to apply the semi-classical model correctly is to forget every thing which was demonstrated by wave mechanical or related arguments after Bohr and Sommerfeld, unless it was (or can be) confirmed by semi-classical arguments.

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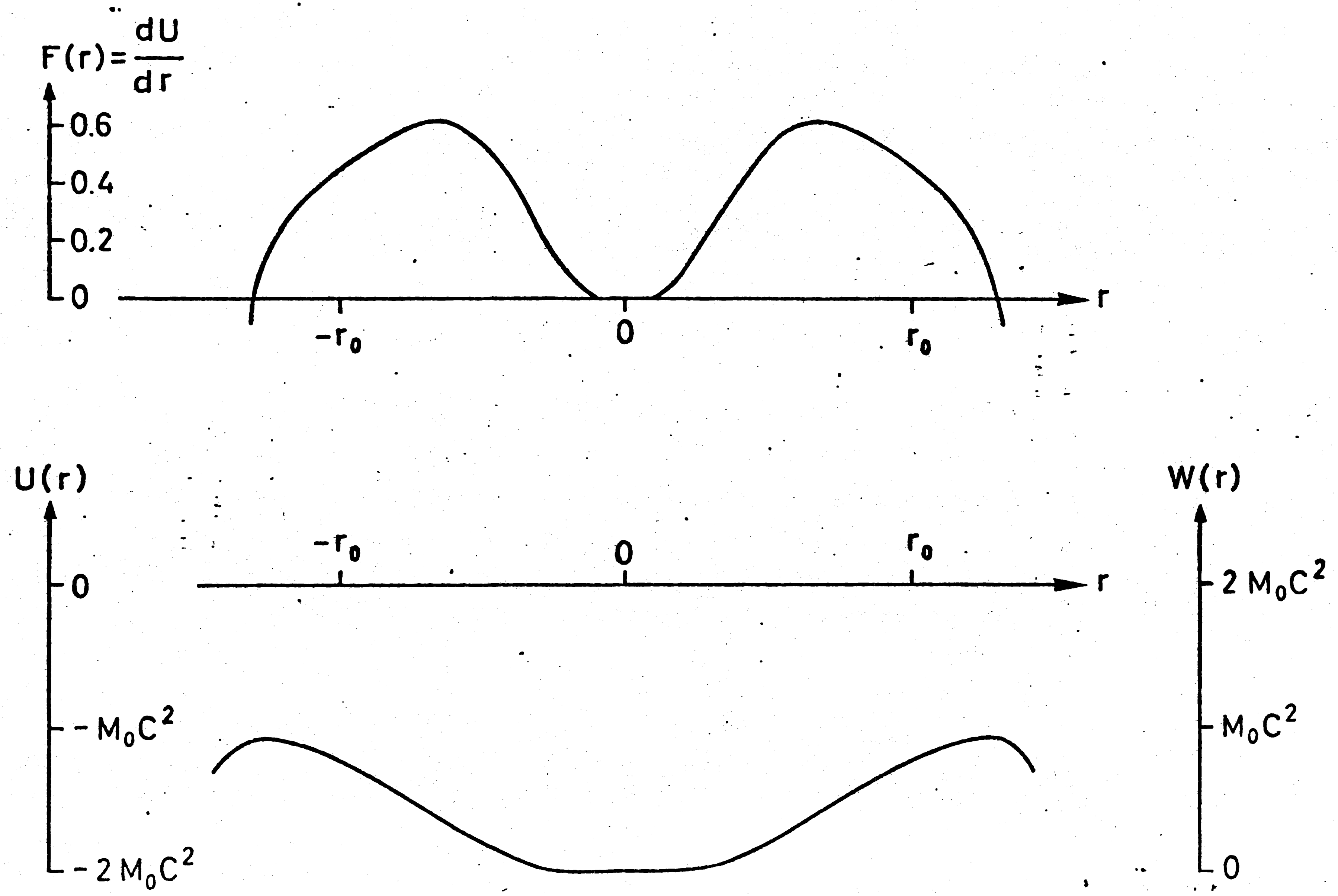
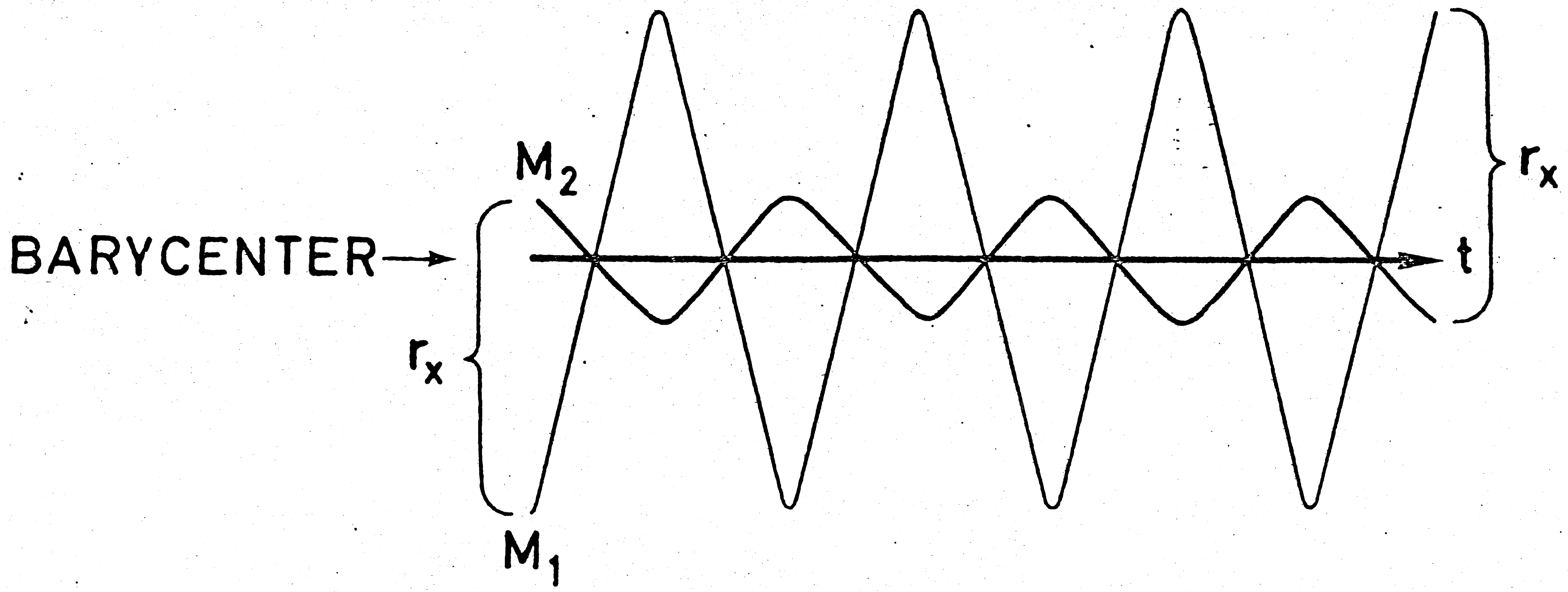


F(r) = dU/dr
0.6
0.4
0.2
0
-r0
0
r0
r
U(r)
0
- M0C2
- 2 M0C2
-r0
0
r0
r
W(r)
2 M0C2
M0C2
0


BARYCENTER
M_2
M_1
r_x
r_x
t

L E G E N D S

Fig. 1

Potential field U defined by formula (5) and its derivative F defining the force field generated by it for two Dirac monopoles of opposite magnetic charge.

The maximum distances between magnetic monopoles in the elementary particles whose masses have been calculated never exceeded 0.7 r_o. Outside this range the above potential and force distribution has therefore not been tested by this or any other method. Furthermore a couple of other potential distributions substantially different from this one have been found which give almost as good results, suggesting that the masses of elementary particles are not as sensitive to the potential distribution as one might expect.

Fig. 2

Oscillatory movements in a binary system in which the rest mass of one particle is 4 times greater than the rest mass of the other one ($M_{20} = 4M_{10}$).