Calculating the Electrical and Magnetic Forces between Two Hydrogen Atoms Using SR Electrodynamics

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This paper is basically a continuation of showing how SR Electrodynamics [1], [2] can be applied in the fields of physics, chemistry, and electrical engineering. First presented are the relevant formulas from SR Electrodynamics. Second is an outline of the math for programming a computer for calculating the magnetic forces between two hydrogen atoms. Third is an outline of the math for programming a computer for calculating the Coulomb or electrical force between two hydrogen atoms. Next presented are computed results of the programs. And lastly is a discussion of the results and their possible application to cold fusion.
Key Words: electrodynamics, special relativity (SR), electric field (e-field), relative moving charges, magnetic force, Coulomb force, magnetic field energy, steady-state, dynamic, induction, cold fusion.

1. Introduction

It was discovered by the author that one can accurately calculate the induced voltage in a single-turn coil, placed at a few meters from a primary coil, using induction formulas from SR Electrodynamics. In the formulation for the formulas of induction in the electrodynamics from SR, the force formulas are derived first. The first one is a force formula for force between relatively moving charges. The second one is a force formula for force between a charge and a current element. This second one was used to derive with vector analysis the classical Ampère's Law determined from Ampère's experiments in about 1822. Experiments performed by the author have verified the accuracy of calculating inductance and induced voltages using the classical Ampère's Law. Therefore the first two derived force laws are deemed by the author to be correct. It occurred to the author that if you can accurately calculate the induced voltage of two coils at a distance, then one could accurately calculate the force between two current carrying coils separated at a distance. Then if one could do that, then one could calculate the forces (magnetic and Coulomb) between two hydrogen atoms from the first derived force formula. One would need to use the mathematical methods used to derive the classical Ampère's Law which is at the heart of the calculations. The methods employed and results may have some bearing on hydrogen cold fusion and chemical reactions.

2. Relevant force formula from SR Electrodynamics

Relativists have determined an equation for the transform of the electric field of a relatively moving electric charge. This equation, Eq. (1), expresses the electric field intensity at a stationary point, emanating from a relatively moving charge q_1 at a 3-vector distance of $\mathbf{r_1}$ (See Figure 1),

$$\mathbf{e_1} = \frac{kq_1\mathbf{r_1}}{\gamma^2 r^3\left[1\text{-}\left(v^2/c^2\right)\sin^2\theta\right]^{\frac{3}{2}}} \tag{1}$$

Where v = magnitude of $\mathbf{v}$, the uniform relative velocity between q_1 and a coordinate system or a stationary point in the coordinate system, $\gamma = 1/\sqrt{1-v^2/c^2}$, θ = angle between $\mathbf{r_1}$ and $\mathbf{v}$. $\hat{\mathbf{r}}_1$, when used, is the unit vector of $\mathbf{r}_1$ and r is it's magnitude. The constants are $k = 1/4\pi\varepsilon_0$ (ε_0 = permittivity of free space) and c = speed of light. In the coordinate system, $q_1$is determined to be moving at the origin while q_2 is stationary, a convention used throughout this paper. Eq. (1), when multiplied by q_2 (See Figure 2), a test charged placed at the stationary point, represents the total electrodynamics force between the stationary charge and the moving charge. This force consists of the electric Coulomb force and the magnetic force. This expression is good for relative velocity from zero up to c.

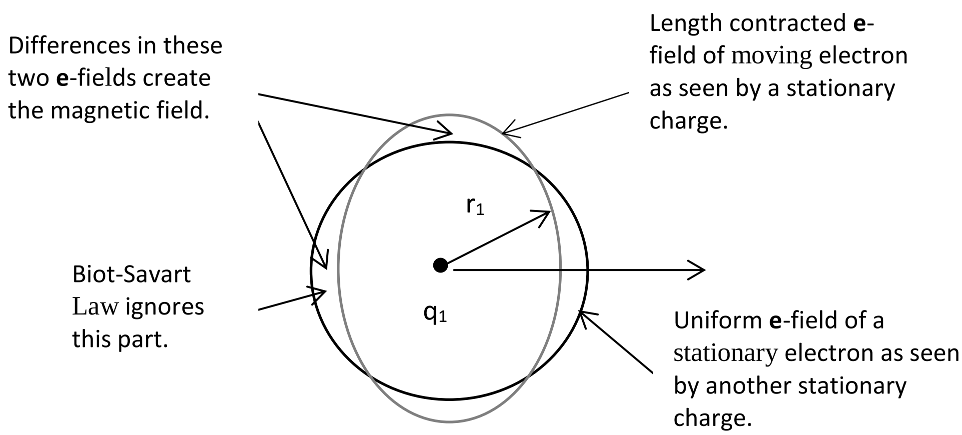

Figure 1. How special relativity (SR) creates the magnet field of moving charges. This shows a cross section of the effect on the e-field of a moving

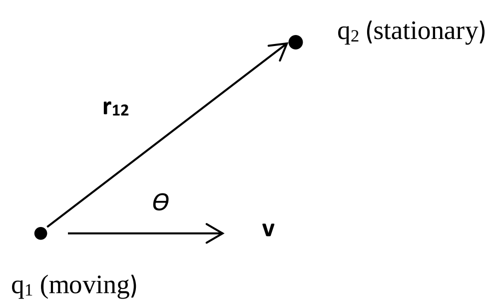

Figure 2. Relation between the vector terms in Eq. (1) and q_2.. Θ is angle between $\mathbf{r_{12}}$ and $\mathbf{v}$.

An equation very similar to the Lorentz Force Law is derived from Eq. (1) using the Binomial Series and eliminating higher order terms of v^2/c^2:

$$\mathbf{f_{12}} = q_2\left[\frac{kq_1}{r^2} + \frac{kq_1}{{r_{12}}^2}\frac{v^2}{c^2}\left(0.5\text{-}1.5\cos^2\theta\right)\right]\hat{\mathbf{r}}_{\mathbf{12}} \tag{2}$$

where $\hat{\mathbf{r}}_{12}$ = unit vector in the direction of $\mathbf{r_{12}}$ and r_{12} = magnitude of the vector $\mathbf{r_{12}}$ joining the two current elements. The constants are $k = 1/4\pi\varepsilon_0 = \mu_o c^2/4\pi$ (ε_0 = permittivity of free space and μ_o = permeability of free space and c = speed of light).

Eq. (2) describes the total force between two relatively slow moving isolated charges. The first term in the brackets describes an uniform **e**-field (Coulomb field) as in the Lorentz Force Law and the second term describes magnetic effects as does the second term in the Lorentz force law. Also, the relative velocity v between the two charges is clearly defined, as in Eqs. (1) and (2), and not obscured as in the Lorentz Force Law. The force in Eq. (3) acts along $\mathbf{r_{12}}$ and does not violate Newton's Third Law as the Lorentz Force Law does. Eq. (2) could be written as:

$$\mathbf{f_{12}} = q_2\left(e_1 + e_{m1}\right)\hat{\mathbf{r}}_{\mathbf{12}} \tag{3}$$

where e_{m1} is the new definition of the magnetic field created by the moving charge q_1:

$$\mathbf{e_{m1}} = \frac{kq_1}{r_1^2}\frac{v^2}{c^2}\left(0.5 - 1.5\cos^2\theta\right)\hat{\mathbf{r}}_1 \tag{4}$$

And $$\mathbf{e_{c1}} = \frac{kq_1}{r^2}$$

(5)

Eq. (5) represents the Coulomb field. As can be seen from Eq. (2), The electrical and magnetic forces obeys Newton's Third Law. The magnetic force depends on the relative velocities between the charges. Note the negative sign in front of the equation: the charges are algebraic in the sense that a negative charge has a minus sign (-) associated with it and a positive charge has a plus sign (+) associated with it. A negative outcome of the equation would represent an increase in the repulsion of the two charges, and a positive result would represent attraction or a decrease in repulsion. Remember (see Figure 2) that in Eq. (2), and all the following equations, θ is the angle between the *relative velocity vector* **v** and the radial vector $\mathbf{r_{12}}$ joining the two charges. Eq. (2) is a "steady-state" equation.

3. The magnetic force between two hydrogen atoms and the mathematics used in the programs

It is recognized that the two hydrogens are not current elements, although there are similarities. We will be using first the magnetic force part of Eq. (2). It is shown here with the k constant replaced with μ_o and its accompanying terms :

$$\mathbf{f}_{12} = \frac{\mu_o q_1 q_2 v^2}{4\pi r_{12}{}^2}\hat{\mathbf{r}}_{12}\left(0.5\text{-}1.5\cos^2\theta\right) \tag{6}$$

Recall that v is the relative velocity magnitude between the charges q_1 and q_2. And Θ is the angle between the relative velocity vector $\overline{v}_R$ and the position vector $r_{12}\hat{\mathbf{r}}$. Note the force vector is in the same direction as the position vector having either a positive value (attraction) or a negative value (repulsion).

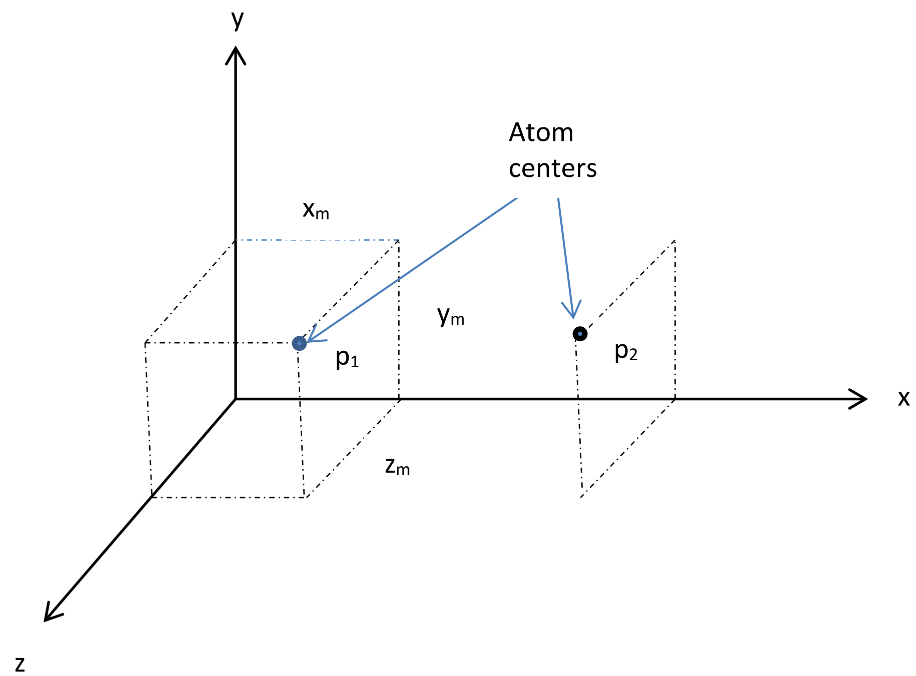

Figure 3. Coordinate representation showing positioning of the two atoms.

We designate Hydrogen Atom one with a subscript 1 and Hydrogen Atom with a subscript 2. See Figure 3. There are three basic magnetic forces which we must add: The force between e_2 (electron_2) and p_1 (proton1), the force between e_1 (electron_1) and p_2 (protron_2), and the force between e_1 and e_2.

The orbit of the electron about the proton of a hydrogen atom is assumed to be a circle with a radius equal to the radius of the first Bohr orbit: $A = 5.2917715\text{x}10^{-11}$ m. The velocity of the electron in the first Bohr orbit is given: $V_b = 2.1864991\text{x}10^6$ m/s. The circumference of the electron orbit is divided into 360 parts with each part containing a charge equal to $e/360$, where $e = 1.60210\text{x}10\text{-}^{19}$ C. See Figure 4.

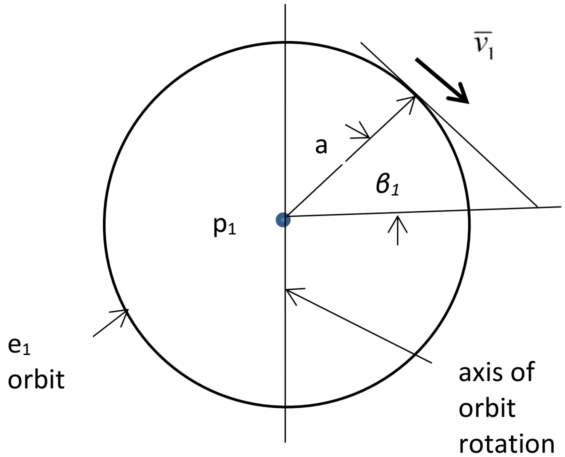

Figure 4. Orbit of electron e_1 around proton p_1

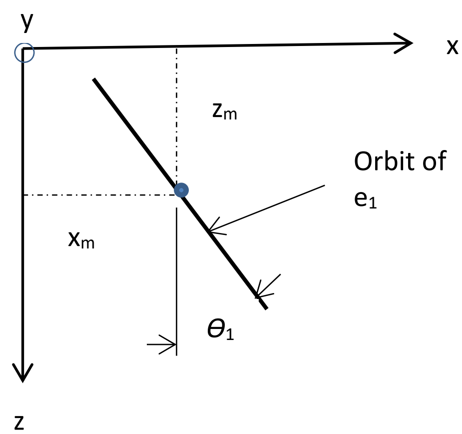

Figure 5. Shows orbit rotation as function of Θ_1.

The *v* in Eq. (6) is the relative velocity of the two charges in the equation. The relative velocity must then be determined between the two orbiting electrons. This is a complicated process, but is possible using vector analysis. The velocity vectors are shown in Figure 6 for analysis.

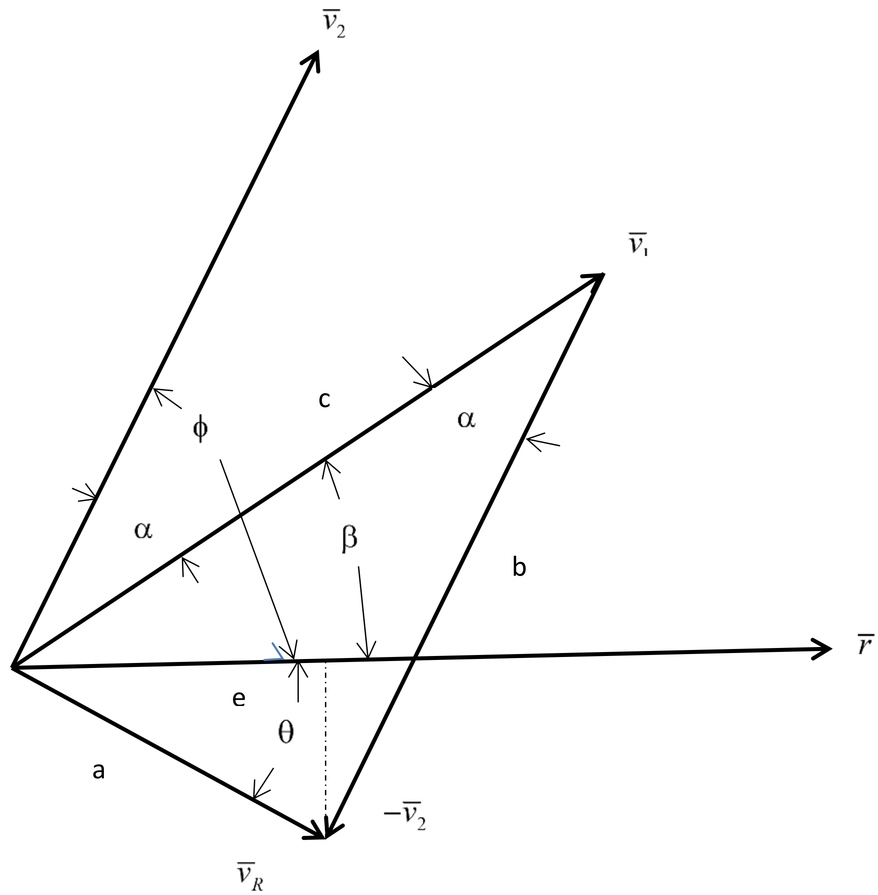

Figure 6. Vector diagram for determining relative velocity vector between two velocity vectors and also the
$\cos(\Theta)$ term of Eq. (6). This is also the important diagram used for deriving the classical Ampère’s Law.

We now perform the following mathematical steps:

Law of cosines: $a^2 = b^2 + c^2 - 2bc\cos(\alpha)$

$$\text{So } v_R{}^2 = v_1{}^2 + v_2{}^2 - 2v_1v_2(\hat{v}_1 \bullet \hat{v}_2) \tag{7}$$

Where $\overline{v}_1 = v_1\hat{v}_1$ and $\overline{v}_2 = v_2\hat{v}_2$ and $\cos(\alpha) = \hat{v}_1 \bullet \hat{v}_2$

$$e = v_1\cos(\beta) - v_2\cos(\phi) = v_1(\hat{v}_1 \bullet \hat{r}) - v_2(\hat{v}_2 \bullet \hat{r}) \tag{8}$$

$$\cos(\theta) = \frac{e}{v_R} \tag{9}$$

There are three basic magnetic forces which we must add: The force between e_2 (electron$_2$) and p_1 (proton1), the force between e_1 (electron$_1$) and p_2 (protron$_2$), and the force between e_1 and e_2. We will consider these forces next.

3.1 The magnetic force between e_2 (electron$_2$) and p_1 (proton1) and the magnetic force between e_1 (electron$_1$) and p_2 (protron$_2$)

These two forces can be calculated with the same math even though the orientation of the electron orbits for a given pair of atoms may be different. The orientation of the orbits (different values of theta, see Figure 5) can have different values for the force. The computer program assumes an uniform distribution of the orbits and takes an average as the final value. It is taken to be the same for both of these forces. Figure 7 shows the basic program routine for calculating these forces. The programming language employed is Turbo Pascal.

```
Procedure Fp1e2Pos;

  Begin
    {Magnetic force between Proton1 and orbiting eletron2, Pos Velocity}
    {fac,Fp1e2,Theta2}

    Beta1 := 0.0;
    Beta2 := 0.0;

    x11 := Xm;
    y11 := Ym;
    z11 := Zm;

    For N2 := 1 to N do
      Begin
        Beta2:=N2*dB;

        x22 := fac*Xm+Ra*cos(Beta2)*sin(Theta2);
        y22 := Ym+Ra*sin(Beta2);
        z22 := Zm+Ra*cos(Beta2)*cos(Theta2);

        r := sqrt((x22-x11)*(x22-x11)+(y22-y11)*(y22-y11)+
        (z22-z11)*(z22-z11));

        r1 := (X22-x11)/r;
        r2 := (y22-y11)/r;
        r3 := (z22-z11)/r;

        v21:= cos(PI/2.0-Beta2)*sin(Theta2);
        v22:= -sin(PI/2.0-Beta2);
        v23:= cos(Theta2)*Cos(Pi/2-Beta2);

        A := r1*v21+r2*v22+r3*v23;

        Fp1e2 :=(r1/(r*r))*(0.5-1.5*A*A) + Fp1e2;

      end;

    Fp1e2 := G1*Fp1e2;

  end;
```

Figure 7. Basic program routine showing how the force between stationary proton$_1$ and orbiting electron$_2$ is computed. It also shows how the above math formulas are applied.

3.2 The magnetic force between e_2 (electron$_2$) and e_1 (electron$_1$)

This force is more complex to calculate because of having to determine the relative velocity between the two electrons which may have different directions and magnitudes. In this program the magnitudes of the velocities are assumed to be the same which is the velocity of the electron in the first Bohr orbit. Figure 8 shows the basic routine for this computation.

```
Procedure Fe1e2Pos1Pos2;
    {Magnetic force between orbiting electrons of the pair}
    {Fe,Theta1,Theta2}
  Label
    Skip1;
  Begin

    Beta1 := 0.0;
    Beta2 := 0.0;

    For N1 := 1 to N do

      Begin
        Beta1 := N1*dB;

        x11 := Xm+Ra*cos(Beta1)*sin(Theta1);
        y11 := Ym+Ra*sin(Beta1);
        z11 := Zm+Ra*Cos(Beta1)*cos(Theta1);

        v11 := cos(Pi/2.0-Beta1)*sin(Theta1);
        v12 := -sin(Pi/2.0-Beta1);
        v13 := cos(Pi/2.0-Beta1)*cos(Theta1);

      For N2 := 1 to N do
        Begin
          Beta2:=N2*dB;

          x22 := fac*Xm+Ra*Cos(Beta2)*sin(Theta2);
          y22 := Ym+Ra*sin(Beta2);
          z22 := Zm+Ra*cos(Beta2)*cos(Theta2);

          r := sqrt((x22-x11)*(x22-x11)+(y22-y11)*(y22-y11)
               +(z22-z11)*(z22-z11));

          v21 := cos(Pi/2.0-Beta2)*sin(Theta2);
          v22 := -sin(Pi/2.0-Beta2);
          v23 := cos(Pi/2.0-Beta2)*cos(Theta2);

          B := v11*v21+v12*v22+v13*v23;

          Vrsqr := 2.0*Ve1*Ve2*(1.0-B);

          r1 := (x22-x11)/r;
          r2 := (y22-y11)/r;
          r3 := (z22-z11)/r;

          C := v11*r1 + v12*r2 + v13*r3;
          D := v21*r1 + v22*r2 + v23*r3;

          L := Ve1*C - Ve2*D;

          Vr:= sqrt(Vrsqr);

          If Vr = 0.0 then goto Skip1;

          H := L/Vr;

          Fe :=(r1*G2*Vrsqr/(r*r))*(0.5-1.5*H*H) + Fe;
        Skip1:
        end;
    end;
  end;
  {------------------------------------------------------------------}
```

Figure 8. Basic program routine showing how the magnetic force between the two orbiting electrons is calculated. It also show how the above math is applied for this function.

In computing the magnetic force between the two orbiting electrons, an uniform distribution of orbit orientations was assumed and computed. Then an average was taken to be representative of this force.

3.3 Top level program routine

This program routine allows for repeated calculations involving changes in distance between the atoms and different orientations of the orbits of the electrons. Figure 9 shows the beginning of the top level program routine.

```
AssignConstants;
fac := 5.0;
faci := 5;

{Magnetic force between Proton1 and electron2,Fp1e2}
For N7 := 1 to 4 do
Begin
  fac := N7*fac;
  faci:= N7*faci;

{Fp1e2Pos}
Theta2 := 0.0;
Fp1e2 := 0.0;

For N3 := 1 to 12 do
  Begin
    Theta2 := N3*Pi/12.0;
    Fp1e2Pos;
  end;
Fp1e2 := Fp1e2/12.0;
Fpet := 2.0*Fp1e2;

Writeln('  Fpet = ',Fpet:11);
writeln;
{---------------------------------------------------}

{Magnetic force between the orbiting electrons of the two H atoms.}

{Fe1e2Pos1Pos2}
Ft := 0.0;

Fe := 0.0;
Theta1 := 0.0;
Theta2 := 0.0;

For N4 := 1 to 6 do
  Begin
    Theta1i := 30*N4;
    Theta1 := Theta1i*Pi/180.0;

    For N3 := 1 to 6 do
      Begin
        Theta2i := 30*N3;
        Theta2 := Theta2i*Pi/180.0;

        If Theta2i = Theta1i then
          Begin
            Theta2 := 0.99 * Theta2;
          end;

        If Theta2i = (Theta1i - 180) then;
          Begin
            Theta2 := 0.99 * Theta2;
          end;

        Fe1e2Pos1Pos2;
      end;
  end;
Ft:= Fe/36.0;
Feet := Ft;

{-------------------------------------------------------------}
```

Figure 9. Beginning of top level routine showing how distance between atoms is varied and different orientation of the orbits of the electrons are varied.

3.4 Results of the computer computation for magnetic force

Figure 10 is a printout showing the magnetic force output of the computer program. The distance between the centers of the two atoms is denoted by "Fac", short for factor. Fac is a factor used to multiply the radius of the electron orbit (used as an unit) to create the distance. Since the distance to the first atom's center is one radius from the origin, one must substract 1 from the Fac number and multiply the results by the radius to get the distance between atom's centers. The first magnetic force printout Fpet in each of the iterations is the calculated force between a proton of one atom and the electron in orbit of the other atom. Fpet is the sum of the two combinations. All Force units are in Newtons. Feet is the magnetic force between the two orbiting electrons. Forcet is the sum of Fpet and Feet.

```
                                      H_FORCET
Fpet =  2.08E-0014
Feet = -5.67E-0014
Fac =     5    Forcet = -3.58E-0014 Newtons

Fpet =  4.43E-0015
Feet = -1.28E-0014
Fac =    10    Forcet = -8.42E-0015 Newtons

Fpet =  4.34E-0016
Feet = -1.28E-0015
Fac =    30    Forcet = -8.44E-0016 Newtons

Fpet =  2.58E-0017
Feet = -7.61E-0017
Fac =   120    Forcet = -5.03E-0017 Newtons
```

Figure 10. Printout of program output showing the calculated average orbital magnetic force between two Hydrogen atoms at various separated distances.

```
                                          GRAVITY1
fac =     5    Fgravity =   4.17E-0045 newtons
fac =    10    Fgravity =   8.24E-0046 newtons
fac =    30    Fgravity =   7.94E-0047 newtons
fac =   120    Fgravity =   4.71E-0048 newtons
```

Figure 11. A printout of a program that calculates the force of gravity between the two Hydrogen Atoms at the same distances as in Figure 10.

3.5 Discussion of results for magnetic force

1. The calculated results are very likely to be values that correspond to reality. This is because the formula employed was a step on the way to the derivation of the classical Ampere’s Law. And this law has been verified in several experiments performed and reported upon by this

author. However this author is not aware of any experiments that would that verify the above results.

2. The magnitudes of the orbital magnet forces are much greater than the force of gravity.

3. The surprising results is the orbital magnetic force is predominately repulsive. It will be shown later that with special orientation of the electron orbits, the magnetic force can be attractive.

4. If there is a force between the two atoms due to the spin of the electrons and protons, it is not considered in this paper.

3.6 In search of orbital orientations for optimal attractive orbital magnetic force

A variation of the computer program was written to search for optimal attractive orbital magnetic force resulting from the orientation of the electron orbits. The distance between the two atoms was held constant and the orientation of the electron orbit of atom$_1$ was set constant with theta1 = 1, 45, and 89 degrees. Theta2 of atom$_2$ was varied from 30 to 180 degrees at 30 degree increments. The directions of the two orbital velocities were set clockwise (CW). Results of the program are shown on Figures 12, 13, and 14. Figure 15 is for when the orbital velocity direction of atom$_2$ was set counter clockwise.

```
                               H_FMAXM1
Fac =  5  Theta1i =   1  CW

Fp1e2 =  8.29E-0014
Fp2e1 =  1.25E-0013
Feet = -1.80E-0013

CW  Theta2i =  30      Ft =  2.81E-0014 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 =  1.25E-0013
Feet = -1.07E-0013

CW  Theta2i =  60      Ft =  4.21E-0015 Newtons

Fp1e2 = -7.02E-0014
Fp2e1 =  1.25E-0013
Feet = -6.66E-0014

CW  Theta2i =  90      Ft = -1.17E-0014 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 =  1.25E-0013
Feet = -1.06E-0013

CW  Theta2i = 120      Ft =  5.03E-0015 Newtons

Fp1e2 =  8.29E-0014
Fp2e1 =  1.25E-0013
Feet = -1.79E-0013

CW  Theta2i = 150      Ft =  2.88E-0014 Newtons

Fp1e2 =  1.25E-0013
Fp2e1 =  1.25E-0013
Feet = -2.13E-0013

CW  Theta2i = 180      Ft =  3.72E-0014 Newtons
```

```
                               H_FMAXM1
Fac =  5  Theta1i =  45  CW

Fp1e2 =  8.29E-0014
Fp2e1 =  3.68E-0014
Feet = -1.18E-0013

CW  Theta2i =  30      Ft =  1.92E-0015 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 =  3.68E-0014
Feet = -3.53E-0014

CW  Theta2i =  60      Ft = -1.25E-0014 Newtons

Fp1e2 = -7.02E-0014
Fp2e1 =  3.68E-0014
Feet =  2.81E-0014

CW  Theta2i =  90      Ft = -5.29E-0015 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 =  3.68E-0014
Feet = -4.89E-0015

CW  Theta2i = 120      Ft =  1.80E-0014 Newtons

Fp1e2 =  8.29E-0014
Fp2e1 =  3.68E-0014
Feet = -9.39E-0014

CW  Theta2i = 150      Ft =  2.58E-0014 Newtons

Fp1e2 =  1.25E-0013
Fp2e1 =  3.68E-0014
Feet = -1.44E-0013

CW  Theta2i = 180      Ft =  1.78E-0014 Newtons
```

```
                               H_FMAXM1
Fac =  5  Theta1i =  89  CW

Fp1e2 =  8.29E-0014
Fp2e1 = -7.01E-0014
Feet = -2.23E-0014

CW  Theta2i =  30      Ft = -9.54E-0015 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 = -7.01E-0014
Feet =  8.33E-0014

CW  Theta2i =  60      Ft = -6.79E-0016 Newtons

Fp1e2 = -7.02E-0014
Fp2e1 = -7.01E-0014
Feet =  1.48E-0013

CW  Theta2i =  90      Ft =  7.78E-0015 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 = -7.01E-0014
Feet =  8.48E-0014

CW  Theta2i = 120      Ft =  7.55E-0016 Newtons

Fp1e2 =  8.29E-0014
Fp2e1 = -7.01E-0014
Feet = -2.13E-0014

CW  Theta2i = 150      Ft = -8.49E-0015 Newtons

Fp1e2 =  1.25E-0013
Fp2e1 = -7.01E-0014
Feet = -6.67E-0014

CW  Theta2i = 180      Ft = -1.17E-0014 Newtons
```

Figure 12. Theta1 = 1 deg. **Figure 13.** Theta1 = 45 deg. **Figure 14.** Theta1 = 89 Deg.

```
                                            H_FMAXM1
Fac =  5  Theta1i =   1  CW

Fp1e2 =  8.29E-0014
Fp2e1 =  1.25E-0013
Feet = -1.80E-0013

CCW  Theta2i =  30     Ft =  2.81E-0014 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 =  1.25E-0013
Feet = -1.07E-0013

CCW  Theta2i =  60     Ft =  4.21E-0015 Newtons

Fp1e2 = -7.02E-0014
Fp2e1 =  1.25E-0013
Feet = -6.66E-0014

CCW  Theta2i =  90     Ft = -1.17E-0014 Newtons

Fp1e2 = -1.39E-0014
Fp2e1 =  1.25E-0013
Feet = -1.06E-0013

CCW  Theta2i = 120     Ft =  5.03E-0015 Newtons

Fp1e2 =  8.29E-0014
Fp2e1 =  1.25E-0013
Feet = -1.79E-0013

CCW  Theta2i = 150     Ft =  2.88E-0014 Newtons

Fp1e2 =  1.25E-0013
Fp2e1 =  1.25E-0013
Feet = -2.13E-0013

CCW  Theta2i = 180     Ft =  3.72E-0014 Newtons
```

Figure 15. Theta1 = 1 deg.
Atom$_2$ electron orbit CCW

3.7 Discussion of results for optimal attractive magnetic force

1. It appears the optimal orbital attractive magnetic force occurs when the planes of the electron orbits are parallel to each other, but not in the same plane. It makes no difference in the direction of the electron velocity in the orbits as seen by Figures 12 and 15.
2. These computations were not performed as a function of distance. Thus it is possible the sign of the force could reverse as a function of distance..
3. In Figure 14 Theta1 was chosen to be 89 degrees instead of 90 degrees because the program "crashes" at 90 degrees.
4. From Figure 14 it is seen that the force is attractive when the planes of the two electron orbits are in roughly the same plane (89 degrees and 90 degrees).

4. The electric (Coulomb) force between two hydrogen atoms

In deriving the classical Ampere's Law for magnetic force between current elements, it was assumed the electric (coulomb) forces, attractive and repulsive forces, would cancel out between the charges of one current element with respect to the charges of the other current element. In this study, this assumption is not made. These forces may not cancel due to geometrical considerations. In fact, this study shows that this force is very much more dominant than the magnetic force. The first term in the bracket of Eq. (2) is employed in the programs calculating the coulomb forces with geometrical considerations. When the electron charge was considered to be uniformly distributed in both orbits, the coulomb force was calculate to be repulsive and much larger than any magnetic attractive force. But there is a possibility this force can be attractive which is considered in the next section.

4.1 The Coulomb force with synchronous orbits

It may be possible that two adjacent hydrogen atoms can have their electrons orbits lock into synchronism with each other. This would be the case where they were at the same quantum level and orbiting at the same velocity and in the same direction. The electrons would be orbiting 180 degrees from one another to position themselves at maximum distance from each other due to their repulsive force to each other. The repulsive force of the electrons and the repulsive force of the protons taken together would then be less than the attractive coulomb forces of the orbiting electrons with the protons of the opposite particle. The computing routine for this situation is shown in Figure 16.

```
                              ELE1E2F2.PAS

 {--------------------------------------------------------}
Procedure EleeTheta;
    {Electric force between orbiting eletrons of the pair}
      {Fe,Theta1,Theta2}

    Begin

      Beta1 := 0.0;
      Beta2 := 0.0;

      For N1 := 1 to N do
        Begin
          Beta1 :=N1*dB;
          Beta2 :=Beta1 + Pi;

          x11 := Xm+Ra*cos(Beta1)*sin(Theta1);
          y11 := Ym+Ra*sin(Beta1);
          z11 := Zm+Ra*cos(Beta1)*cos(Theta1);


          x22 := fac*Xm+Ra*cos(Beta2)*sin(Theta2);
          y22 := Ym+Ra*sin(Beta2);
          z22 := Zm+Ra*cos(Beta2)*cos(Theta2);

          r := sqrt((x22-x11)*(x22-x11)+(y22-y11)*(y22-y11)+
                   (z22-z11)*(z22-z11));

          r1 := (X22-x11)/r;
          r2 := (y22-y11)/r;
          r3 := (z22-z11)/r;

          Fe := r1/(r*r) + Fe;

        end;

        Fe :=-G3*Fe;
    end;
```

Figure 16. Computer routine for calculating the repulsive force of the two synchronous orbiting electrons.

The attractive force of the electron in one orbit with the proton of the other atom is calculated in the same manner as for the magnetic forces except for have a much greater multiplying factor. The repulsive force of the proton charges is calculated with the standard Coulomb formula. The calculations for the total Coulomb force between the two atoms is presented in Figures 17-19.

```
                                   H_FMAXE2.DAT
Fac =  5  Theta1i =   1  CW

EFp1e2 =  4.85E-0009
EFp2e1 =  4.70E-0009
Feet = -8.95E-0009

CCW  Theta2i =  30      Ft =  6.02E-0010 Newtons

EFp1e2 =  5.20E-0009
EFp2e1 =  4.70E-0009
Feet = -9.26E-0009

CCW  Theta2i =  60      Ft =  6.35E-0010 Newtons

EFp1e2 =  5.41E-0009
EFp2e1 =  4.70E-0009
Feet = -9.63E-0009

CCW  Theta2i =  90      Ft =  4.78E-0010 Newtons

EFp1e2 =  5.20E-0009
EFp2e1 =  4.70E-0009
Feet = -9.75E-0009

CCW  Theta2i = 120      Ft =  1.51E-0010 Newtons

EFp1e2 =  4.85E-0009
EFp2e1 =  4.70E-0009
Feet = -9.61E-0009

CCW  Theta2i = 150      Ft = -6.06E-0011 Newtons

EFp1e2 =  4.70E-0009
EFp2e1 =  4.70E-0009
Feet = -9.51E-0009

CCW  Theta2i = 180      Ft = -1.12E-0010 Newtons

Felavg =  2.82E-0010 Newtons
```

Figure 17. Synchronous orbit. Fac = 5, Theta1i = 1 degs.

```
                                   H_FMAXE3.DAT
Fac =  5  Theta1i =  45  CW

EFp1e2 =  4.85E-0009
EFp2e1 =  5.01E-0009
Feet = -9.36E-0009

CCW  Theta2i =  30      Ft =  5.05E-0010 Newtons

EFp1e2 =  5.20E-0009
EFp2e1 =  5.01E-0009
Feet = -9.92E-0009

CCW  Theta2i =  60      Ft =  2.86E-0010 Newtons

EFp1e2 =  5.41E-0009
EFp2e1 =  5.01E-0009
Feet = -1.05E-0008

CCW  Theta2i =  90      Ft = -1.29E-0010 Newtons

EFp1e2 =  5.20E-0009
EFp2e1 =  5.01E-0009
Feet = -1.06E-0008

CCW  Theta2i = 120      Ft = -3.85E-0010 Newtons

EFp1e2 =  4.85E-0009
EFp2e1 =  5.01E-0009
Feet = -1.01E-0008

CCW  Theta2i = 150      Ft = -2.42E-0010 Newtons

EFp1e2 =  4.70E-0009
EFp2e1 =  5.01E-0009
Feet = -9.68E-0009

CCW  Theta2i = 180      Ft =  3.10E-0011 Newtons

Felavg =  1.08E-0011 Newtons
```

Figure 18. Synchronous orbit. Fac = 5, Theta1i = 45 degs.

```
                                   H_FMAXE4.DAT
Fac =  5  Theta1i =  91  CW

EFp1e2 =  4.85E-0009
EFp2e1 =  5.40E-0009
Feet = -1.02E-0008

CCW  Theta2i =  30      Ft =  1.01E-0010 Newtons

EFp1e2 =  5.20E-0009
EFp2e1 =  5.40E-0009
Feet = -1.10E-0008

CCW  Theta2i =  60      Ft = -4.18E-0010 Newtons

EFp1e2 =  5.41E-0009
EFp2e1 =  5.40E-0009
Feet = -1.16E-0008

CCW  Theta2i =  90      Ft = -7.51E-0010 Newtons

EFp1e2 =  5.20E-0009
EFp2e1 =  5.40E-0009
Feet = -1.10E-0008

CCW  Theta2i = 120      Ft = -3.91E-0010 Newtons

EFp1e2 =  4.85E-0009
EFp2e1 =  5.40E-0009
Feet = -1.01E-0008

CCW  Theta2i = 150      Ft =  1.27E-0010 Newtons

EFp1e2 =  4.70E-0009
EFp2e1 =  5.40E-0009
Feet = -9.61E-0009

CCW  Theta2i = 180      Ft =  4.99E-0010 Newtons

Felavg = -1.39E-0010 Newtons
```

Figure 19. Synchronous orbit. Fac = 5, Theta1i = 91 degs.

4.2 Discussion of results

1. The Coulomb forces between the two hydrogen atoms are several orders of magnitude greater than the magnetic forces between the two atoms when the electrons are in synchronous orbits and when the atoms are in close proximity.
2. The attractive Coulomb forces are maximized when the orbits are at around 90 degrees with respect to each other.

5. Conclusion

A primary purpose of this paper and program is to illustrate how the formulas for force between isolated relatively moving charges can be applied. This is an application of SR Electrodynamics. It illustrates calculations that are possible to do and that are accurate. While the calculations require a computer and are complex, the results are worth the effort.

These general techniques can be applied in programs for calculating the force between atoms with more than one proton and one electron.

The attractive force of hydrogen atoms at small distances with synchronous orbits suggest a way cold hydrogen fusion may occur.

The formulas of SR Electrodynamics are powerful. They should not be discounted by physics. They apply to broad ranges of applications from electric motors, rail guns, to atoms.

5. References

[1] J. Keele, "Experimental Support for SR Electrodynamics", http://cybermesa.com/~jkeele9/, (2019).

[2] J. Keele, "Induction in SR Electrodynamics with Experimental Support", http://cybermesa.com/~jkeele9/, (2020).

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