Charged particle attraction and repulsion explained.

A detailed mechanism based on particle wave-functions.

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Abstract

The phenomenon of electrical attraction and repulsion between charged particles is well known, and described mathematically by Coulomb's Law, yet until now there has been no explanation for *why* this occurs. There has been no mechanistic explanation that reveals what causes the charged particles to accelerate, either towards or away from each other. This paper gives a detailed explanation of the phenomena of electrical attraction and repulsion based on my previous work that determined the exact wave-function solutions for both the Electron and the Positron. It is revealed that the effects are caused by wave interactions between the wave-functions that result in Electromagnetic reflections of parts of the wave-functions of the particles, causing a change in their momenta.

Explanation

As seen in earlier work [1,2] the wave functions of the Electron and Positron comprise a three-dimensional spiral wave that is rotating, such that there is a flow of wave phase either outwards or inwards (depending if the particle is negatively or positively charged). These spiral wave structures can be further broken down into the sum of inwardly and outwardly traveling waves.

There is an energy balance between inward and outward waves (i.e. inflow = outflow, resulting in no net energy loss/gain for the particle as a whole). The frequencies, amplitudes & speeds of the waves are set such that the energies of the inward & outward waves are identical & each can become the other when Doppler shifted at the nodes. This is a guaranteed feature of the wave-functions, as they are mathematical solutions to both the Classical and Schrödinger wave equations. For example, a higher frequency outward wave contains the same energy as the inward wave because its amplitude is lower – two effects balance out exactly.

For an Electron there exists, at any point in space, a phase-drift outward with respect to the Electron's centre. This phase drift causes the attraction/repulsion associated with the electric field when it interacts with other charged particles. As one moves further from the Electron's centre, the amplitude of the waves decreases, so too does the

electric field and its associated force due to these waves (i.e. lower wave amplitude = lower momentum in waves = lower force on other charged particles).

When the electric field of the Electron interacts with other charged particles (for example another identical electron), the inward and outward waves of each Electron overlap. When this happens, at the interface between the two Electrons (exactly equal distances between each electron's centre) the two outward waves will form a standing wave and the two inward waves will form a standing wave – each of these standing waves will have no phase drift as an equal amount of each frequency Electromagnetic wave is coming from each side of the interface point in space. Thus, the nodes of the standing wave at this point will not be moving.

The outward wave of the electron normally forms the inward wave when it reflects off a moving node (causing the wave number change between the outward and inward waves), but at this midway point the node is not moving, and so the outward wave will be reflected to form an inward wave of higher frequency than usual (Doppler shifted). Similarly, the nodes from the electron's centre to the midway point become progressively slower, until at the midway point the node stops completely. Thus, the interface between two electrons provides a frequency conversion, or momentum change, to the inward/outward waves. These frequency/momentum changes will propagate through each node to the electron's centre causing the whole electron to move – thus the electron has been accelerated.

When Electromagnetic waves reflect perfectly, they impart a radiation pressure equal to twice the incident radiation pressure. So, by identifying all the points in space where such reflection is occurring, over the region containing the two (or more) charged particle wave functions that are interacting, it is possible to calculate an overall radiation pressure that is acting on the particle. When this is done (for example between two Electrons, two Positrons, or an Electron and a Positron) the total force acting on each particle can be determined. Then, by using Newton's 2nd Law (F=ma), the acceleration of each particle can be determined. For two Electrons or two Positrons, the wave reflections occur predominantly in the space between the two particles – thus causing an outward force that repels each particle from the other. For an Electron and a Positron, the regions that reflect are predominantly outside the two-particle system – thus causing an inward, attractive force between the two particles. The following two figures are plots of the magnitude of the reflected Electromagnetic energy in the x-axis direction for two different modelled configurations: (1) Two Electrons, (2) An Electron and a Positron.

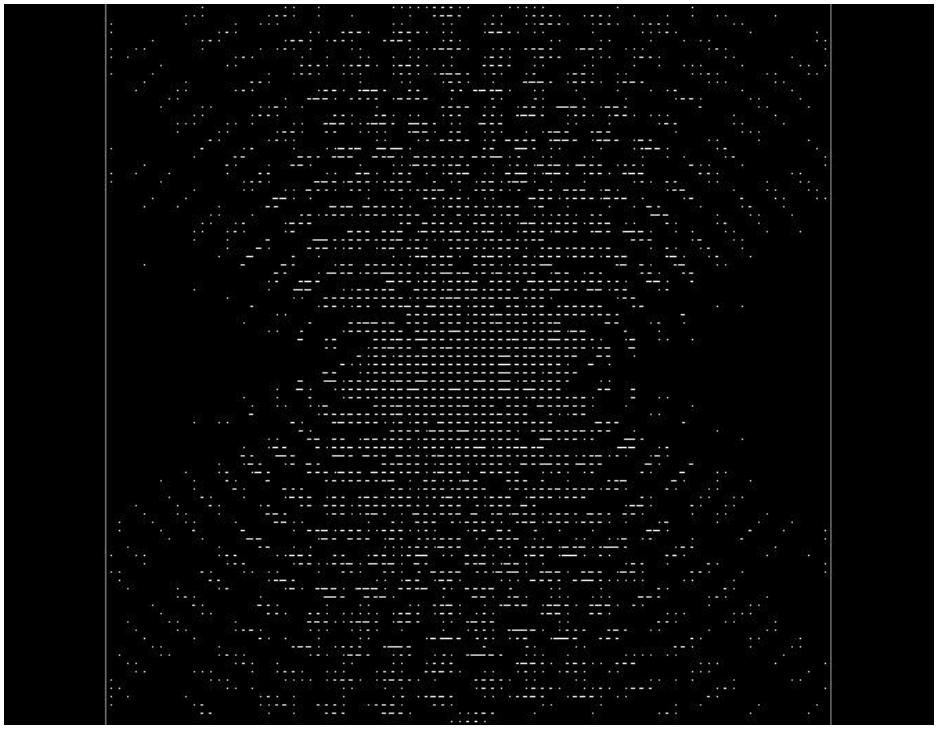

Figure (1) Wave reflections between two Electrons.

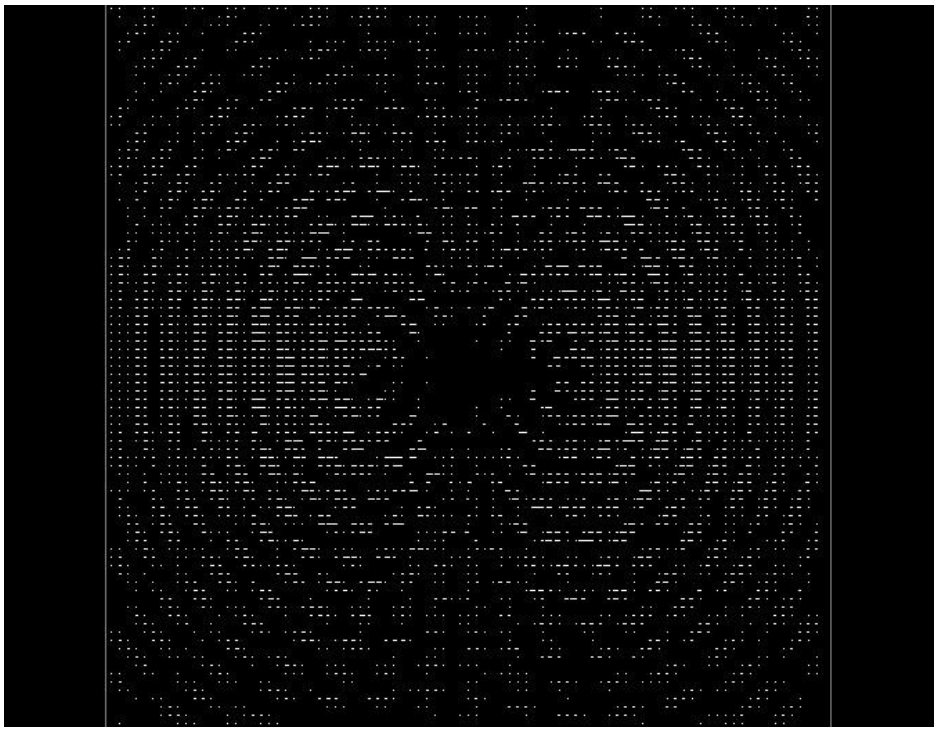

Figure (2) Wave reflections between an Electron and a Positron.

The amount of power coupling between the two particles (electrons) depends on the amount of reflection of the waves from each particle. This amount depends on the minimum power of the two interacting waves along the axis connecting the two particle

centres (the x-axis in this model), as the waves can only reflect when equal but opposite EM wave components meet at the reflection point.

The power values of each EM wave are calculated from the Poynting Vector (vector cross product) of the instantaneous Electric and Magnetic field values of the minimum power of the two interacting waves at each point. As these values are instantaneous, the RMS of these values must be taken to get the actual, effective value [4]:

Electric energy density: $u_e = \frac{\varepsilon_0 \cdot \varepsilon_{RMS}^2}{2}$

RMS in 1 dimension (along the line connecting the two particle centres):

$$\varepsilon_{RMS} = \frac{E}{\sqrt{2}}$$

$$\therefore u_e = \frac{\varepsilon_0 \cdot \varepsilon_{RMS}^2}{2} = \frac{\varepsilon_0 \cdot E^2}{4}$$

However, the electron wave-function varies sinusoidally in all of its three dimensions, so the RMS must be taken over all three dimensions:

$$\varepsilon_{RMS} = \frac{E}{\sqrt{2}\sqrt{2}\sqrt{2}}$$

$$\therefore u_e = \frac{\varepsilon_0 \cdot \varepsilon_{RMS}^2}{2} = \frac{\varepsilon_0 \cdot E^2}{16}$$

There is an additional factor that determines the amount of power coupling between the two particles - the relative orientations of the polarizations of the two waves & how much they align and thus reflect off each other. As the interface area between the two electrons is a circle, the amount of coupling between the two EM waves will vary sinusoidally (around this circle) with the angle difference between the polarizations of the two waves.

However, this effect is taken care of as the dot product of the two EM waves is used to determine the amount of reflection during the calculation of the total reflected

power between the two particles' wave-functions. See **Appendix A** for an extract of the code used to determine the acceleration between the two electrons.

The Power value obtained is then converted into a pressure by dividing by the speed of light. To work out the actual force between the two particles we need to simplify the calculation by reducing each particle to a point particle at its wave-function centre, with an effective area of interaction of one grid point in the model. The force between them is due to wave reflections at the mid-way point between them - where waves from each side are equal.

In a similar way to the Shell Theorem for gravity, where the force between two bodies due to the mass of one spherical body can be treated as all coming from a single point at that spherical body's centre, the attractive/repulsive force between charged particles can be treated similarly.

If we start from the situation where both particles are together at the same point, then there is a single grid point of area interacting between them. As the particles move apart, the volume of the sphere from each particle's centre to the mid-way point between them represents all of the contributing grid points to the total force attributed to the central point.

So, in order to keep the area of interaction between the particles as one grid point of area, in the calculation we must divide by the rate of increase in volume (V) of the sphere with the distance from the mid-way point (R), which is dV/dR.

As the volume of a sphere is:

$$A = \frac{4}{3}\pi R^3, \qquad \frac{dV}{dR} = 4\pi R^2$$

Then expressing this in terms of the separation distance (r) between the particles (r = 2R), we have:

$$4\pi R^2 = 4\pi \left(\frac{r}{2}\right)^2 = \pi r^2$$

Where r is the number of grid points between the two particle centres.

Once this has been done, the actual force between the two particles can be determined by multiplying this pressure by the area of a single grid point.

So, the total Electromagnetic power (P) imparted on each particle is:

$$P = \frac{1}{\pi r^2} \sum \left(P_A \frac{1}{16}\right) dA$$

Where P_A is the instantaneous Electromagnetic power at each area element within the modelled region.

Thus, the Instantaneous Pressure [3] is:

$$\mathrm{I} = \frac{\mathrm{P}}{\mathrm{c}}$$

Where c is the speed of light.

The acceleration of the particle is thus:

$$A = \frac{F}{m}$$

When the model is run (for two Electrons repelling), and the results are recorded for a range of different modelled data points in the 3D space, a graph can be obtained comparing the calculated Electron Acceleration compared to the known Electron acceleration (determined using Coulomb's Law). I have done this for a x, y, and z-axis data points ranging from 100 to 270 data points along each axis. Due to memory constraints on the computer I cannot model a region of space with more than 270 points along each axis, but as you can see from the following graph, as the number of modelled points increases (and thus the accuracy of the calculation), the percentage match between the model and the known acceleration approaches 100%.

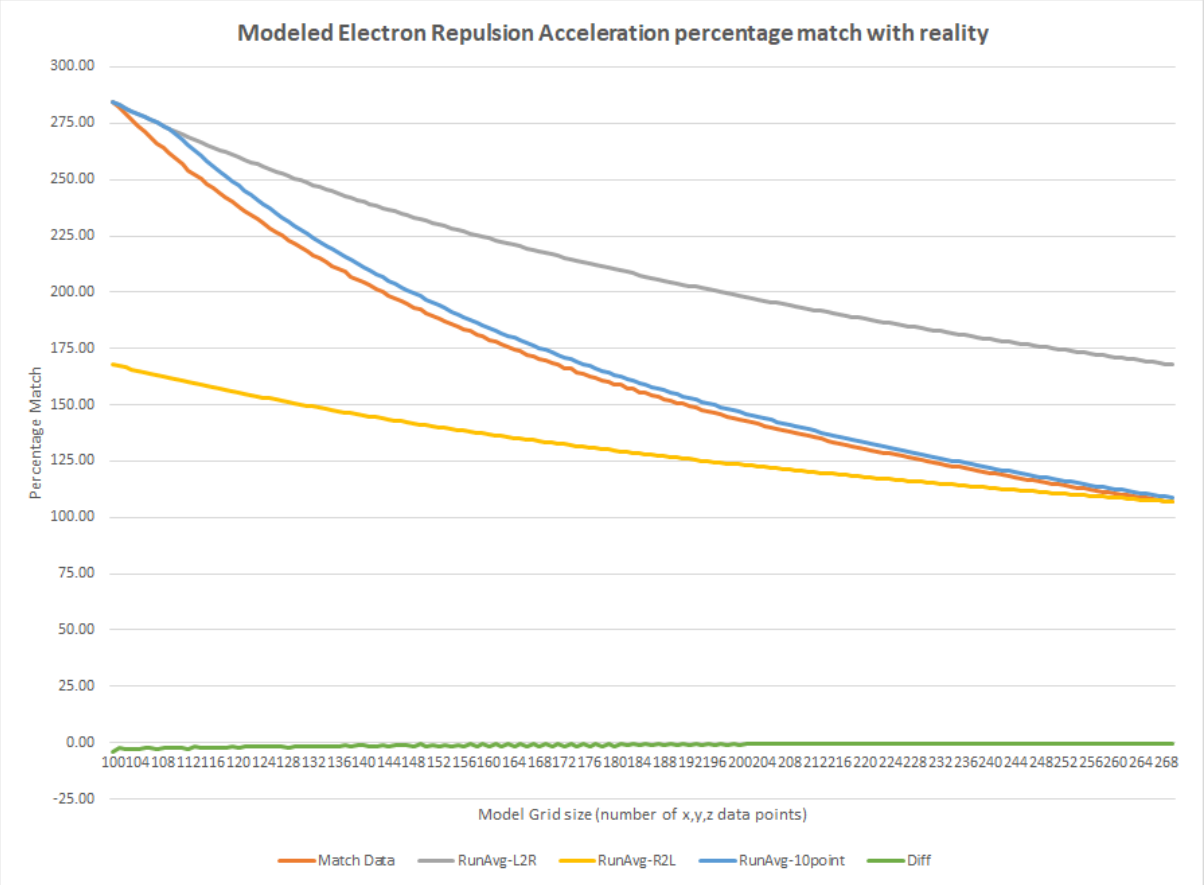

Figure (3) Percentage match between the model and reality over number of modelled grid points. Modelled space was 6.0E-11 metres cubed. The separation of the two electrons was 6.0E-11 metres.

As you can see the accuracy of the model's calculations increases as the number of modelled points increases and the curve asymptotes to a 100% match with the expected electron acceleration (given by Coulomb's Law).

There are 4 curves plotted in Figure (3). They are as follows:

(1) The actual percentage match value for a given model configuration.
(2) A continuous running average value, starting with the first data point (on the Left-Hand side of the graph and moving to the Right).
(3) A continuous running average value, starting with the last data point (on the Right-Hand side of the graph and moving to the Left).
(4) A 10-point windowed running average value of the match data.
(5) The amount of difference between successive data points.

Also, a plot can be made of the modelled acceleration between the two electrons over a range of particle separations (from 1% to 100% of the actual modelled width; which in this case is 5.8E-11 meters):

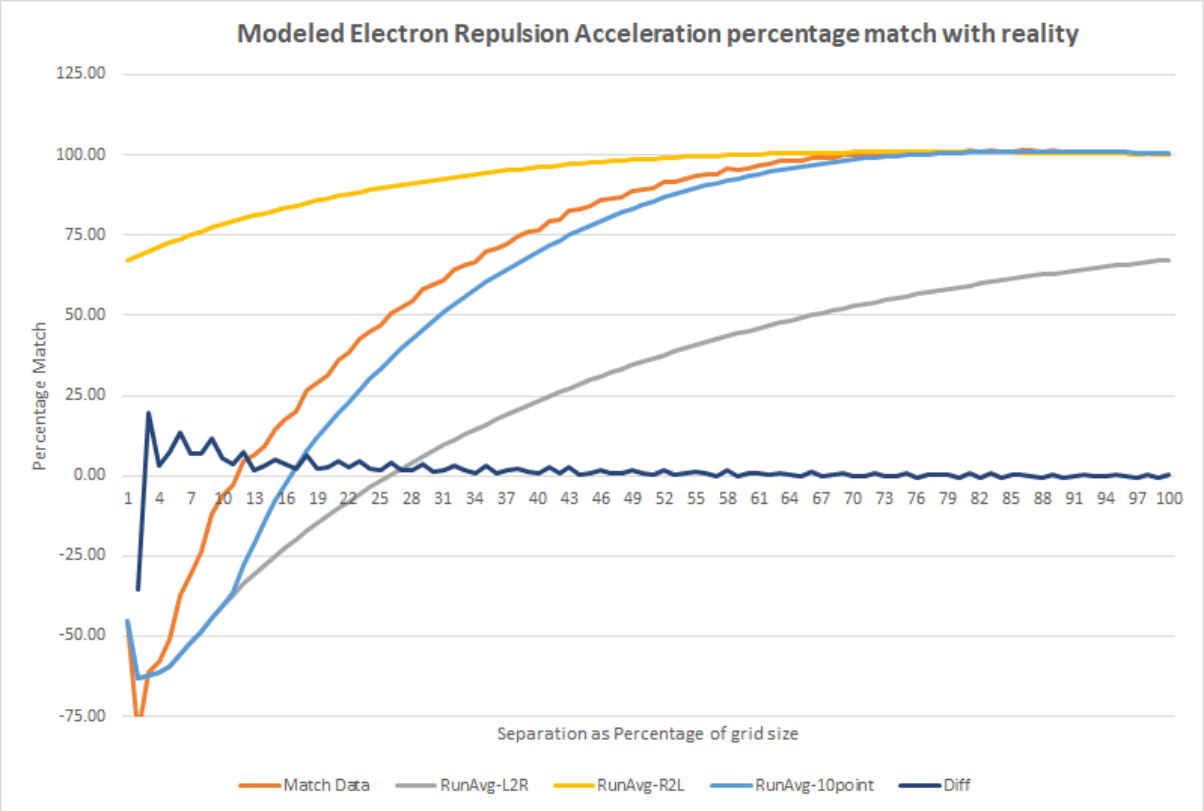

Figure (4) Percentage match between the model and reality over separation distance as a percentage of the modelled space. Modelled space was 5.8E-11 metres cubed.

As you can see from the plot, at very short ranges, the normally repulsive force between the electrons becomes attractive. This effect is a known effect. See reference [5] for discussion on this in regards to Casimir forces, but my finding may also be contributing to the observed charge clumping at high charge densities.

Then at about 10% of the distance (5.8E-12 metres), the force between the two electrons becomes repulsive, and reaches about 100% of the expected classical value from about 72% of the modelled distance onwards. This distance equates to about 4.176E-11 metres between electron centres.

With all of these model calculations there is a balance between the size of the actual physical space being modelled and the number of modelled data grid points within that space. To get more accurate calculations we need a larger number of data points per wavelength of the electron wave-function's waves, but to get a greater proportion of the electron's energy being included in the calculations, we need a greater physical size of the space being modelled.

These two requirements work in opposite directions, and due to memory constraints and computation time, the maximum number of data points along each size of the modelled cube of space is 270. Doubling the number of points down each side results in 8 times as many points in space, and each data point in the model's code holds a lot of different data for each of the possible fields being calculated when the model runs, which has the effect of multiplying the memory requirements by a lot more than 8.

The two graphs I have presented here are about as good a balance between these competing requirements that I can achieve with my current modelling capability. I'm sure that someone with a supercomputer could do a much better job of this modelling, but unfortunately, I do not have one nor have access to one.

Appendix A:

The code used to determine the acceleration from the two particle's wave-functions.

```
PowerCount_neg:=0;
PowerSum_neg:=0;
PowerCount_pos:=0;
PowerSum_pos:=0;

p1_p2_diff:=abs(particle2_x - particle1_x);

for xpos:=0 to GridWidth-1 do begin {scan grid's x coords}
  for ypos:=0 to GridHeight-1 do begin {scan grid's y coords}
    for zpos:=0 to GridDepth-1 do begin {scan grid's z coords}
      Power_x1:=particle1_Power[xpos, ypos, zpos].x;
      Power_x2:=particle2_Power[xpos, ypos, zpos].x;

      vect:=particle1_E[xpos,ypos,zpos];
      vect2:=particle2_E[xpos,ypos,zpos];
      vect.x:=0;
      vect2.x:=0;
      vect:=Normalize(vect);
      vect2:=Normalize(vect2);
      dot_v1v2:=abs(VectorDot(vect,vect2));

      // The Force imparted upon reflection is double the incident radiation pressure
      reflected_power:=2*dot_v1v2*min(abs(Power_x1),abs(Power_x2));

      ReflectedPowerAtPoint:=0;

      if ((Power_x1 > 0) and (Power_x2 < 0)) then begin
        if (xpos > particle1_x) and (xpos < particle2_x) then begin
          ReflectedPowerAtPoint:=ReflectedPowerAtPoint - reflected_power;
        end
        else begin
          ReflectedPowerAtPoint:=ReflectedPowerAtPoint + reflected_power;
        end;
      end
      else if ((Power_x1 < 0) and (Power_x2 > 0)) then begin
        if (xpos > particle1_x) and (xpos < particle2_x) then begin
          ReflectedPowerAtPoint:=ReflectedPowerAtPoint - reflected_power;
        end
        else begin
          ReflectedPowerAtPoint:=ReflectedPowerAtPoint + reflected_power;
        end;
      end;
```

```
    if ReflectedPowerAtPoint < 0 then begin
      Inc(PowerCount_neg);
      PowerSum_neg:=PowerSum_neg + ReflectedPowerAtPoint;
    end
    else begin
      Inc(PowerCount_pos);
      PowerSum_pos:=PowerSum_pos + ReflectedPowerAtPoint;
    end;

  end; // for zpos
 end; // for ypos
end; // for xpos

// Total Pressure = The sum of both the Positive & Negative Power
// divided by speed of light
Pressure:=(PowerSum_neg + PowerSum_pos)/SpeedOfLight;

// The actual pressure at a single, central grid point is 1/πr^2,
// where r is the number of grid points between the two particle centres.
Pressure:=Pressure/(Pi*sqr(GridWidth*p1_p2_diff*dx/ActualWidth));

// Total force is pressure * the area of 1 point
Force:= Pressure*PointArea;

Accel:=Force/ElectronMass; // F = m*a

ExpectedAccel := sqr(ElectronCharge)/sqr(ActualWidth*(p1_p2_diff/GridWidth));
ExpectedAccel := ExpectedAccel * Ek/ElectronMass;

AccelPercentageMatch := 100*Accel/ExpectedAccel;
```

References

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