The Geometry of Spacetime and the Unification of the Electromagnetic, Gravitational and Strong Forces

Jeff Yee* & Lori Gardi†

* *jeffsyee@gmail.com*
† *lori.anne.gardi@gmail.com*

October 5, 2019
(second draft)

Abstract: In this paper, a spacetime structure consisting of a body-centered cubic lattice is modeled classically as a spring-mass system, where the components of each unit cell in the lattice are based on the fundamental units discovered by Max Planck, and the common forces that govern the motion of particles in spacetime is defined and unified by geometric shapes as the spacetime lattice oscillates.

Introduction

In the early 1900s, three-dimensional space and time were linked by Albert Einstein into what became known as a single word – spacetime – to describe the mathematics of relativity. Yet Einstein didn't describe the mechanism for the curving of spacetime nor how it bends and contorts to cause gravity [1]. Years prior to Einstein's work, Max Planck discovered and established a number of constants that simplify the mathematics of the universe – known as the Planck units – but he was not able to describe the meaning of these constants [2]. Here, the Planck units are applied as the fundamental units of length, mass and time to define the geometry of spacetime and explain the natural forces that cause the motion of particles within its domain. There is a reason that the Planck constants fit elegantly into equations that represent the energy and forces of the universe.

If spacetime is considered to be a structure that curves, the structure that is *curving* must be defined. Similarly, if particles and photons are considered to be wave-like, the structure that is *waving* must be defined. Here, the structure of spacetime at the smallest of levels – the quintessence of the universe – is proposed to be a material in a lattice structure of repeating unit cells, where each of the cells may vibrate in harmonic motion such as Fig. 1.

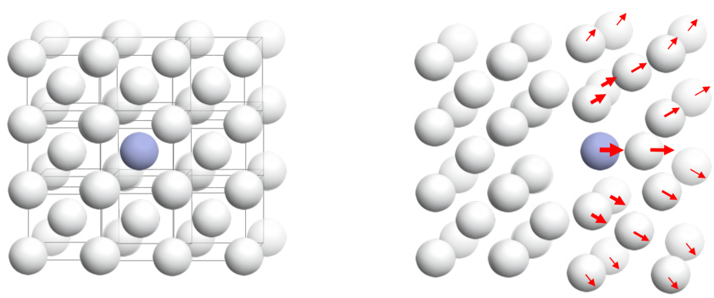


Fig. 1 – Spacetime lattice – no vibration (left); cascading effect of vibration (right)

This structure is responsible for the forces that cause the motion of particles, including the electric, magnetic, gravitational and strong forces. It is also responsible for the energies of photons and particles. In this paper, these forces, the energy of photons, and the energy of the electron will be derived and explained using only five total constants and the geometry of spacetime. Three of these constants (Planck length, Planck mass and Planck charge) are shown in the next figure to describe a unit cell of the spacetime lattice. It will also be shown that a unit cell exhibits behavior similar to a spring-mass system, and as a result, can be calculated using classical mechanics.

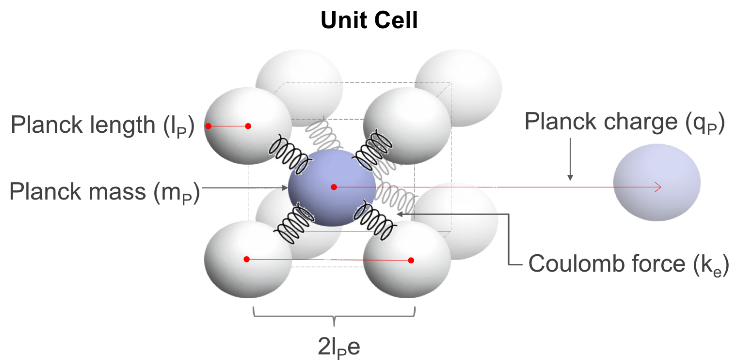


Fig. 2 – Spacetime unit cell

The process to define the unit cell began with a wholistic view of force and energy equations, which often have either mass or charge as variables. Using Modified Unit Analysis (MUA), these equations were first consolidated in units, by relating mass to charge. This was reported in the first of three papers that form the baseline for this paper – *The Relationship of Mass and Charge* [3]. The key finding was the exchange of the units of charge (Coulombs) to units of distance (meters) to relate these properties. Charge is defined here as the displacement distance of a unit cell. The remaining two papers that form the baseline of this paper also describe relationships – *The Relationship of the Mole and Charge* and *The Relationship of the Fine Structure Constant and Pi*. These papers define the separation distance of unit cells and the body-centered cubic structure (bcc) of the spacetime lattice respectively [4, 5].

It is the geometry of spacetime that defines particles and their motion. In this paper, it will be shown that the structure of spacetime can be modeled as a bcc lattice structure, where the repeating structure known as unit cells contain the properties discovered by Max Planck for the values of Planck mass, Planck length, Planck time and Planck charge. It is why the Planck unit system fits nicely into physics equations modeling energy and forces.

The unit cells of the spacetime lattice may expand and contract in harmonic motion, creating the presence of waves that form the basis of particles as standing waves and the forces that cause the motion of particles as traveling waves. All of which can be traced back to a single unit cell and the motion of its components, referred to here as granules, as they spread linearly or spherically due to the structure of the bcc unit cell.

The purpose of this paper is to develop a framework for the underlying structure of the universe, so that it can be modeled with classical mechanics and simulated with computer programs to describe the energy and motion of subatomic particles. The paper first describes the basic unit system and how it is applied to the geometry of spacetime. Then, it offers proof of the calculations and unification of forces by deriving and explaining the fundamental physical constants that are used in force and energy equations and are known to match experimental evidence, such as the Coulomb constant (k_e) for electric forces and the gravitational constant (G) for gravity. More than a dozen fundamental physical constants are derived throughout this paper as such proof.

1. The Universe in Simplified Units (kg, m, s)

All of the equations for forces and energies can be simplified to three units for mass, distance and time. This forms the fundamental kg/m/s unit system. What Max Planck found naturally in the constants for Planck mass, Planck length and Planck time were tiny values when compared against these units in our human reference frame – one that had already been established for kilograms (kg), meters (m) and seconds (s) in our macro world. But the smallest unit cells of spacetime are orders of magnitude smaller than our world. These Planck units form the reference point of an object that occupies the space at the center of the spacetime unit cell – hereafter referred to as a *granule*. The spacetime unit cell can be represented by a center granule that has a mass of Planck mass (m_P), a radius of Planck length (l_P), and when in motion at a universal speed, it takes Planck time (t_P) to travel one Planck length. The value of Planck mass is deceiving because it is significantly larger than the mass of the electron or proton, yet it occupies a much smaller space. It is colored blue in this paper as a center granule that represents the collective mass of granules in motion, collectively the mass in a spring-mass system. It will be shown that the energy from this mass is only recognized when a granule is in motion, similar to a spring-mass that has mass but has no energy unless the mass is displaced from equilibrium.

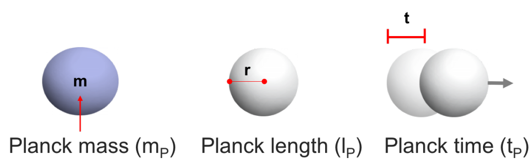


Fig. 1.1 – The basic Planck units for the kg/m/s unit system

The values for each of the basic Planck units are:

$$m_P = 2.17643 \cdot 10^{-8}\ (kg) \qquad \textbf{(1.1)}$$

$$l_P = 1.61625 \cdot 10^{-35}\ (m) \qquad \textbf{(1.2)}$$

$$t_P = 5.39125 \cdot 10^{-44}\ (s) \qquad \textbf{(1.3)}$$

The previous three Planck constants apply to the default units of mass, length and time. Two additional constants are required for the foundation of five constants that can derive everything in this paper. The remaining two constants are related to the electron: the Planck charge (q_P) is the granule displacement at the center of the electron, and the electron's classical radius (r_e) is the distance from the center of the electron where standing waves transition to traveling waves. Both will be described in further detail later in this paper.

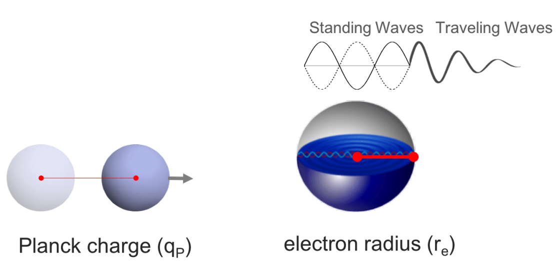


Fig. 1.2 – Electron wave amplitude and wave transition radius

The values for both of these are measured as a distance, in units of meters. Eqs. 1.1 to 1.5 are the **only five constants** required. Everything else in this paper will be derived from these five constants.

$$q_P = 1.87555 \cdot 10^{-18}\,(m) \tag{1.4}$$

$$r_e = 2.81794 \cdot 10^{-15}\,(m) \tag{1.5}$$

Unit Relationships

In the simplified kg/m/s unit system, there are only three units required for all equations. But there are also fundamental constants that relate each of these units. Distance and time can be linked together as meters per second (m/s), otherwise known as speed. And mass and distance can be linked together as kilograms per meter (kg/m), otherwise known as a linear density.

The fundamental speed of the universe is the speed of light (c), which is the relationship of the Planck length to Planck time as shown in Eq. 1.6.

$$c = \frac{l_P}{t_P} = 2.99792 \cdot 10^{8}\left(\frac{m}{s}\right) \tag{1.6}$$

The fundamental linear density is the magnetic constant (μ_0), shown in Eq. 1.7 as the relationship between Planck mass and Planck length, including a geometric ratio (x) that will be explained in Section 3. For the magnetic constant to be recognized correctly in kilograms per meter units, the unit of charge (Coulombs) is replaced with the unit of distance (meters).

$$\mu_0 = \frac{m_P}{l_P}(x) = \frac{m_P}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right) = 1.2566 \cdot 10^{-6}\left(\frac{kg}{m}\right) \tag{1.7}$$

2. The Geometry of Spacetime

Nature often repeats itself and nature often finds a way to optimize. The proposed structure of the spacetime lattice includes repeating cells, called a unit cell in the study of molecules. Nature is likely repeating itself from the smallest of structures as it builds. A body-centered cubic (bcc) structure of a unit cell with a separation length (a) is described in Fig. 2.1. In the bcc structure, a granule exists in the center of the unit cell and eight granules are located at the vertices of the cube. Each of these granules has a radius of Planck length, and a diameter of twice this length (2 * l_P). Euler's number (e) is the base of the natural logarithm and often found in nature. The total separation length of the unit cell is a granule diameter times Euler's number (2 * l_P * e). It is nature's way of optimization and it is found in the separation length of granules in the unit cell.

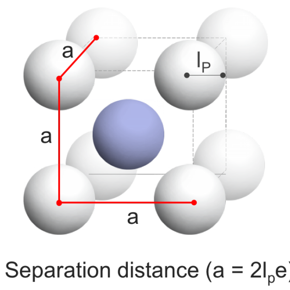


Fig. 2.1 – Unit cell granule separation length (e is Euler's number)

In Fig. 2.1, the center granule is color coded in blue. It is meant to signify that this granule is at the center of vibration, such as Fig. 2.2. If it vibrates and the total displacement is a distance of Planck charge, it collides with and has a cascading effect on other granules. Collectively, they form a spherical wavefront with a longitudinal wavelength (λ) that is also based on Euler's number ($2 * q_P * e^2$), but it is now the square of Euler's number as it will be calculated based on the surface area of a sphere.

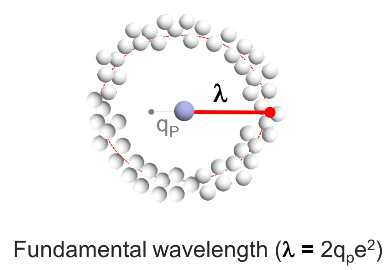


Fig. 2.2 – Granule harmonic displacement and wavelength

The relationships of separation distance of granules in a unit cell (a) and the separation of granules when traveling as longitudinal waves (λ) are expressed in Eqs. 2.1 and 2.2. They will be proven later in the derivation of Avogadro's constant and the fundamental frequency respectively. Euler's number (e) is 2.71828…

$$a = 2l_Pe \tag{2.1}$$

$$\lambda = 2q_Pe^2 \tag{2.2}$$

2.1 Rectangle-to-Sphere (Surface Area Ratio)

The surface area relationship of a rectangle compared to a sphere is the first key geometric shape ratio, **describing plane waves versus spherical waves**. Plane waves converging upon a center equally from all directions will be reflected outwards and will appear to be spherical - this will be later described as particles. Further from the center, the motion in any given direction can be described as plane waves. These two areas describe the surface penetration of granule wave motion. A granule in motion may be displaced from equilibrium as it vibrates, affecting nearby granules as it transfers its energy. Yet the collective energy of all granules measured at these surface areas will be shown to be equal and conserved. A plane wave can be represented by the surface area of a rectangle (S_r) with width (x) and length (y), and the spherical wave with the surface area of a sphere (S_s) with radius (l). Both are described in the next figure.

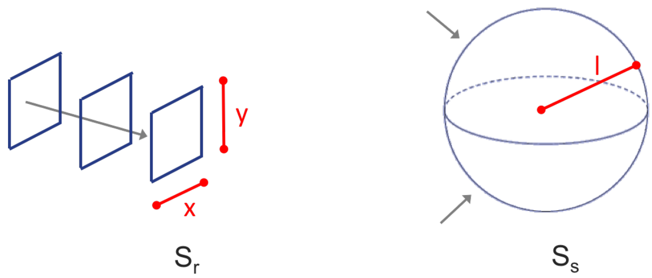


Fig. 2.1.1 – Surface areas of a rectangle (S_r) and a sphere (S_s) representing plane and spherical waves

The surface areas of a rectangle (S_r) and a sphere (S_s) are as follows:

$$S_r = xy \tag{2.1.1}$$

$$S_s = 4\pi l^2 \tag{2.1.2}$$

The first of two key geometric ratios is the ratio of the rectangle-to-sphere surface area (Eq. 2.1.3). It is labelled with the alpha character (α_1) due its relationship with the coupling constants of forces, as will be explained in this section.

$$\alpha_1 = \frac{S_r}{S_s} = \frac{xy}{4\pi l^2} \tag{2.1.3}$$

Example

The electron's classical radius (r_e) is used for the values of all three variables in Eq. 2.1.3. The notation of the function which is used later follows this format to assign three variables to the equation:

$$\alpha_1 \{x = r_e, y = r_e, l = r_e\} \tag{2.1.4}$$

When setting all variables to the electron's radius, the result is the inverse of 4π, which often appears in electromagnetic equations:

$$\alpha_1 = \frac{xy}{4\pi l^2} = \frac{r_e^2}{4\pi r_e^2} = \frac{1}{4\pi} \tag{2.1.5}$$

2.2 Rectangle-to-Sphere+Cone (Surface Area Ratio)

The second key geometric relationship is a slight variation of the first - the surface area of a cone is added to the sphere. This geometry remains the same across forces but the amplitude displacement and direction will be the difference and cause of the strong, electric, magnetic and gravitational forces. In physics equations, the relationship of these forces relative to the electric force is described by coupling constants. For example, the fine structure constant (α or α_e) expresses the dimensionless ratio between the electric force and strong force [6]. These coupling constants can be derived mathematically from a single geometric relationship.

The surface area of a rectangle represents the penetration of a shape such as the unit cell by a granule in (1) in Fig. 2.2.1. In a bcc unit cell, the center granule colored blue is illustrated moving in (2), hitting maximum displacement and reversing in (3) and finally returning to equilibrium in (4). This motion has a direct effect on the granules at the vertices of the unit cell which spread spherically, having a cascading effect on other unit cells. At the same time, the motion of the center granule may also affect the motion of the center granule of the next unit cell, possibly introducing spin if not in complete alignment. This motion also cascades and the geometry can be represented by a cone. The surface areas of the sphere and cone are added together as any granule in touch with any point on these surface areas may cause a change in amplitude.

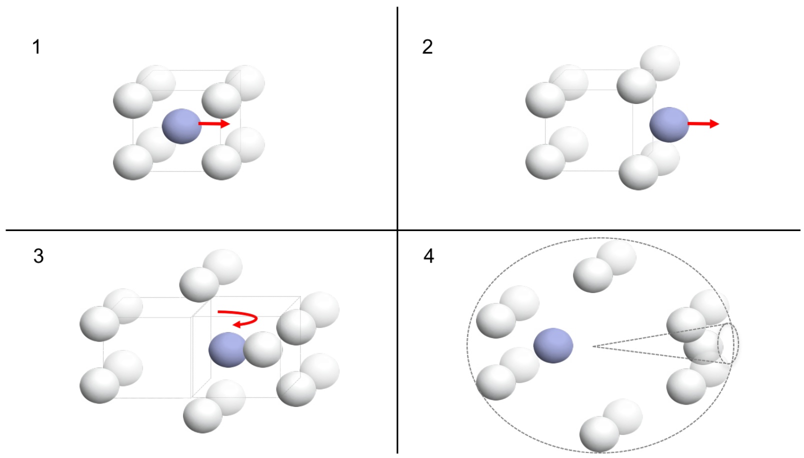


Fig. 2.2.1 – Vibration of center granule

In this harmonic motion, the displacement and return to equilibrium is a π cycle and can be represented by a sine wave with a half wavelength. The ratio of a rectangular surface area (S_r) will be compared to the surface area of a sphere **plus** cone (S_s+ S_c). The width and height of the rectangle is x and y. The radius of the cone is d, and the slant length of both the cone and the radius of the sphere is l. Furthermore, slant length (l) is related to cone radius by π * d. This was described in detail in *The Relationship of the Fine Structure Constant and Pi* paper due to the difference between the time that it takes for a granule to vibrate and return to equilibrium and the time that it takes for a granule that is traveling in one direction at constant speed. It is also described visually later in Fig. 3.2.1.

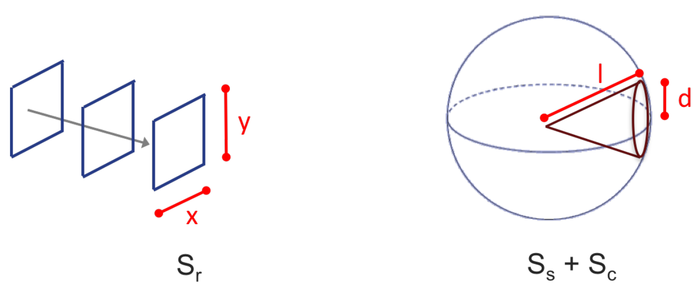


Fig. 2.2.2 – Surface areas of a rectangle (S_r) and a sphere+cone (S_s+S_c)

The sphere and cone geometries are found in the formation of magnetic lines, which is likely replicating what is occurring at a micro-level when atom configurations have the right alignment of electron spin (such as magnets).

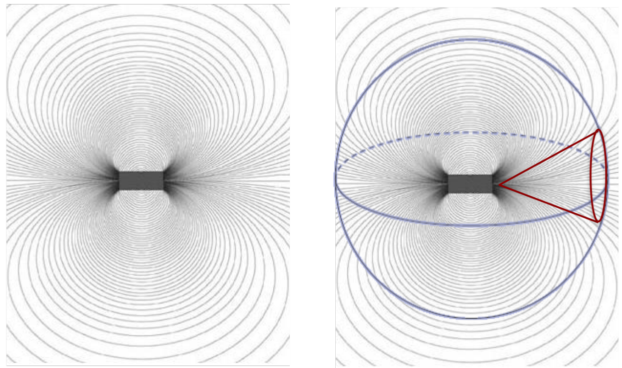


Fig. 2.2.3 – Sphere and cone geometries seen in magnetic lines (left – bar magnet; right bar magnet with overlay of sphere+cone)

The surface area of a cone is:

$$S_c = \pi d l + \pi d^2 \quad \textbf{(2.2.1)}$$

Now, equation 2.1.3 is expanded to include the addition of the cone's surface area in the denominator. This becomes the second of two key geometric ratios used in this paper (α_2).

$$\alpha_2 = \frac{S_r}{S_s + S_c} = \frac{xy}{4\pi l^2 + (\pi d l + \pi d^2)} \quad \textbf{(2.2.2)}$$

Example

The electron's classical radius (r_e) is used for the values of all four variables in Eq. 2.2.2 (and slant length is multiplied by radius times π). The notation of the function which is used later follows this format to assign four variables to the equation:

$$\alpha_2 \{x = r_e, y = r_e, d = r_e, l = \pi r_e\} \quad \textbf{(2.2.3)}$$

When the length and width distances are the same as the radius of the cone, such as when they are all set to the electron's classical radius, the value is equal to the **fine structure constant (α)**.

$$\alpha_2 = \frac{xy}{4\pi l^2 + (\pi d l + \pi d^2)} = \frac{r_e^2}{4\pi (\pi r_e)^2 + (\pi (r_e)(\pi r_e) + \pi r_e^2)} = \frac{1}{4\pi^3 + \pi^2 + \pi} = 0.00729734 \quad \textbf{(2.2.4)}$$

All calculations of fundamental physical constants in this paper are shown in the format *equation* = *value* (*units*) and match known CODATA values of the constants [7]. The fine structure constant, however, is dimensionless and thus no units appear in this equation. This special version of this geometric ratio at the electron radius is given the label $\boldsymbol{\alpha_e}$ as it is related to the electron.

$$\alpha_e = \alpha_2 = \frac{1}{4\pi^3 + \pi^2 + \pi} \quad \textbf{(2.2.5)}$$

3. Forces as an Effect of Spacetime Geometry

The forces that affect the motion of particles can be mathematically derived based on the conservation of energy and geometric ratios from the previous section. It begins with the energy of a center granule with mass of Planck mass and radius of Planck length, as illustrated.

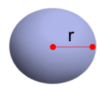


Fig. 3.1 – Granule of Planck mass and radius of Planck length

The energy of this center granule can be expressed with Einstein's well-known equation in Eq. 3.1, and the force at the surface of this granule by dividing the distance of Planck length (l_P) in Eq. 3.2.

$$E = m_P c^2 \quad \textbf{(3.1)}$$

$$F = \frac{m_P c^2}{l_P} \quad \textbf{(3.2)}$$

All of the forces in the upcoming sections will be based on Eq. 3.2, with the inclusion of one or both of the geometric ratios (α_1 and α_2) from Section 2. They will all have the following format:

$$F = \frac{m_P c^2}{l_P} (\alpha_1)\,(\alpha_2) \quad \textbf{(3.3)}$$

3.1 The Fundamental Force and the Magnetic Constant

The first geometric ratio is used to prove the fundamental force that exists as constant wave motion between particles, captured as the magnetic constant or its inverse as Coulomb's constant. Assuming that waves travel throughout the universe and form wavefronts according to Huygen's principle [8], the convergence of these wavefronts on a spherical granule (radius of Planck length) is represented by a plane *in-wave* with a displacement distance (amplitude) of Planck charge.

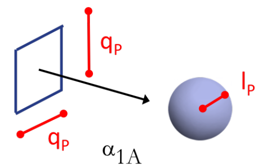


Fig. 3.1.1 – Plane wave representation of in-waves converging on a sphere with radius of Planck length (α_{1A})

This geometric ratio (α_{1A}) is applied to Eq. 3.3. As an **in-wave**, it is the inverse of the ratio:

$$F = \frac{m_P c^2}{l_P}\left(\frac{1}{\alpha_{1A}}\right) \quad \textbf{(3.1.1)}$$

The geometry ratio for a plane wave to spherical wave was established in Eq. 2.1.3. Using the function described in Eq. 3.1.2, the variables for x and y are set to Planck charge (q_P) and l is set to Planck length (l_P). It is substituted into Eq. 3.1.1 to become the fundamental force on a granule.

$$\alpha_{1A} = \alpha_1\{x = q_P, y = q_P, l = l_P\} = \frac{q_P^2}{4\pi l_P^2} \quad \textbf{(3.1.2)}$$

$$F = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right) \quad \textbf{(3.1.3)}$$

The previous equation can be rearranged to separate c^2, showing the full derivation of the **magnetic constant** (μ_0):

$$F = \frac{m_P}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)c^2 \quad \textbf{(3.1.4)}$$

$$\mu_0 = \frac{m_P}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right) = 1.2566 \cdot 10^{-6}\left(\frac{kg}{m}\right) \quad \textbf{(3.1.5)}$$

It also shows that the magnetic constant is a linear density (kg/m) when the units of charge are correctly identified as a distance (meters). The magnetic constant is now substituted into Eq. 3.1.4 for readability. This simplified format will be used in upcoming sections proving forces and energies.

$$F = \mu_0 c^2 \quad \textbf{(3.1.6)}$$

3.2 The Strong Force

All of the forces, including the strong force, are measurements at a point in space relative to the center of a particle. This introduces a variable (r) to measure a force at this given distance.

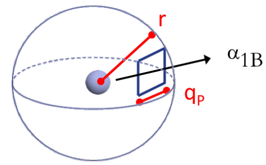


Fig. 3.2.1 – Reflected spherical out-wave (α_{1B}) measured as a plane wave at a variable distance r

This geometric ratio (α_{1B}) is applied to the in-wave equation (Eq. 3.1.1), representing the spherical out-wave that will be measured at a variable distance (r). Energy is perfectly conserved, but the displacement of each granule decreases as energy spreads across a greater number of granules when spreading spherically. Thus, the force decreases and is proportional to α_{1B}/α_{1A}.

$$F_s = \frac{m_P c^2}{l_P}\left(\frac{\alpha_{1B}}{\alpha_{1A}}\right) \quad \textbf{(3.2.1)}$$

The geometric ratio of the rectangle-to-sphere is used again, but now with a variable distance that represents the radius of the sphere that is being measured. The function describing this geometry with Planck charge and a variable distance uses Eq. 2.1.3. α_{1B} is then inserted into the previous equation and finally simplified in Eq. 3.2.4.

$$\alpha_{1B} = \alpha_1\{x = q_P, y = q_P, l = r\} = \frac{q_P^2}{4\pi r^2} \quad \textbf{(3.2.2)}$$

$$F_s = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r^2}\right) \quad \textbf{(3.2.3)}$$

$$F_s = \mu_0 c^2\left(\frac{q_P^2}{4\pi r^2}\right) \quad \textbf{(3.2.4)}$$

It is labelled as a strong force (F_s) but it may be best described as the *pure* reflection of energy as either longitudinal or transverse waves measured at a given distance from the center of a particle. In a separate paper on the *Geometry of Particles*, this equation is used to determine the forces and energies of particles from the neutrino to the Higgs boson [9] as longitudinal waves. Here in this paper, the equation is used to prove the strong, transverse wave force in the nucleus of atoms.

The strong force is responsible for binding quarks together to form protons and neutrons and its residual force binds these particles together to form the nucleus of atoms. It occurs only at short distances, explained by the possibility that particles may be stable at the nodes of standing waves, and further that standing waves occur within the boundary of a particle's radius (e.g. the electron's radius). This is further described as the energy and mass of the electron in Section 5.

3.3 The Electric Force

The electric force is an expansion of the previous strong force, but now adds the consideration of spin within particles like the electron. Energy is always conserved, but now the reflected energy is not purely longitudinal or transverse in form. It is a mix of both wave forms. The longitudinal form will be shown in this section to be the electric force; the transverse form will be shown in the next Section 3.4 to be the magnetic force.

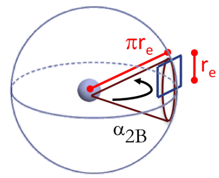


Fig. 3.3.1 – Reflected spherical out-wave (α_{2B}) and the spin of a particle with two wave forms: longitudinal and transverse

A geometric ratio that describes this energy split into two wave forms is appended to Eq. 3.2.1 from the strong force.

$$F_e = \frac{m_P c^2}{l_P}\left(\frac{\alpha_{1B}}{\alpha_{1A}}\right)(\alpha_{2B}) \tag{3.3.1}$$

The ratio for the electron (α_{2B}) uses the second of two key geometric ratios described in Section 2. Now, it will use the ratio of the rectangle to sphere+cone geometry as a result of introducing particle spin. Since it is based on the electron, the electron's radius (r_e) is used for the variables in the equation for this ratio, which was earlier derived to be the fine structure constant (α_e). It is inserted into Eq. 3.3.1 above and simplified.

$$\alpha_{2B} = \alpha_2\{x = r_e, y = r_e, d = r_e, l = \pi r_e\} = \frac{r_e^2}{4\pi(\pi r_e)^2 + (\pi(r_e)(\pi r_e) + \pi r_e^2)} = \frac{1}{(4\pi^3 + \pi^2 + \pi)} = \alpha_e \tag{3.3.2}$$

$$F_e = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r^2}\right)(\alpha_e) \tag{3.3.3}$$

$$F_e = \mu_0 c^2\left(\frac{\alpha_e q_P^2}{4\pi r^2}\right) \tag{3.3.4}$$

The constant for the elementary charge (e_e) is often used as the charge of a single electron. This relationship between the elementary charge, Planck charge and the fine structure constant is shown next and then simplified.

$$e_e^2 = \alpha_e q_P^2 \tag{3.3.5}$$

$$F_e = \mu_0 c^2\left(\frac{e_e^2}{4\pi r^2}\right) \tag{3.3.6}$$

The electric force (F_e) is rarely measured as the interaction of a single electron or proton. It is typically measured as a collection of particles, adding particles together for the collective charge. This mechanism for adding charges together will be described as constructive wave interference in Section 4. For now, the total charge (q) can be described as a change in amplitude as a result of a number of elementary charges, expressed in Eq. 3.3.7.

$$q = \Delta e_e \tag{3.3.7}$$

$$F_e = \mu_0 c^2 \left(\frac{\Delta e_e \Delta e_e}{4\pi r^2} \right) = \mu_0 c^2 \left(\frac{qq}{4\pi r^2} \right) \tag{3.3.8}$$

Eq. 3.3.8 is the electric force of multiple particles separated at distance (r). However, it is more commonly expressed as **Coulomb's law**. Coulomb's constant is a combination of all the constants found in Eq. 3.3.8. Once all the variables are separated to the right side, the electric force in its common form can be found in Eq. 3.3.10.

$$k_e = \frac{\mu_0 c^2}{4\pi} \tag{3.3.9}$$

$$F_e = k_e \left(\frac{qq}{r^2} \right) \tag{3.3.10}$$

3.4 The Magnetic Force - *Monopole*

In the previous section on the electric force, longitudinal wave energy is reduced as it is reflected outwards due to the spin of the electron. Due to the conservation of energy principle, this energy must take another form. The second form is a transverse wave due to spin, and its force becomes the magnetic force.

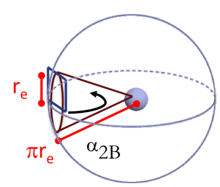


Fig. 3.4.1 – The geometry of the magnetic monopole force is identical to the electric force (α_{2B}) but is now the inverse

This geometric ratio (α_{2B}) is identical to the electric force except that it is now the inverse. It appears in the denominator of Eq. 3.4.1 to become the magnetic force for a single particle (F_m).

$$F_m = \frac{m_P c^2}{l_P} \left(\frac{\alpha_{1B}}{\alpha_{1A}} \right) \left(\frac{1}{\alpha_{2B}} \right) \tag{3.4.1}$$

The magnetic force of a single particle is a monopole, which is not a common equation because monopoles are not stable in nature. The next section will derive a more common dipole magnet. However, the magnetic moment of a single electron can be derived and is found in the Bohr magneton. The proof of the following equation for the magnetic force of a monopole will be shown in the derivation of the Bohr magneton later in Section 5.9.

$$F_m = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r^2}\right)\left(\frac{1}{\alpha_e}\right) \quad \textbf{(3.4.2)}$$

$$F_m = \mu_0 c^2\left(\frac{q_P^2}{4\pi\alpha_e r^2}\right) \quad \textbf{(3.4.3)}$$

3.5 The Magnetic Force - *Dipole*

The magnetic force of dipole magnets, which decreases in strength at the cube of distance from the source, is a slight variation of the previous monopole magnetic force. The previous figure for magnetism is now modified for two particles (left of Fig. 3.5.1) that have an effect on a third particle (right of Fig. 3.5.1) at a variable distance (r).

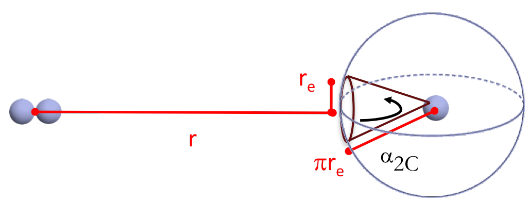


Fig. 3.5.1 – The geometry of a magnetic dipole (α_{2C}); two particles (left) have a force on a particle (right)

This geometry may apply to two particles such as a proton and electron. But it also may apply to two quarks within a proton. For the latter reason, this force is labeled as F_o because of the effect it has on an electron in the orbit of an atom. This will be proven in Section 5 for the calculation of electron orbital distances and energies, including the Bohr radius.

The strong force equation (Eq. 3.2.1) now includes this geometric ratio (α_{2C}) that describes this transformation. Like the magnetic monopole force, it is inverse.

$$F_o = \frac{m_P c^2}{l_P}\left(\frac{\alpha_{1B}}{\alpha_{1A}}\right)\left(\frac{1}{\alpha_{2C}}\right) \quad \textbf{(3.5.1)}$$

The same geometric ratio used for the fine structure constant (α_2) is applied again. This time, there is one difference. The x value is now variable, which is the distance (r) to the third particle. Using the variables described in the function in the next equation, they are inserted into Eq. 2.2.2 and solved. Eq. 3.5.2 is then substituted into Eq. 3.5.1 and simplified.

$$\alpha_{2C} = \alpha_2\{x = r, y = r_e, d = r_e, l = \pi r_e\} = \frac{r(r_e)}{4\pi(\pi r_e)^2 + (\pi(r_e)(\pi r_e) + \pi r_e^2)} = \frac{r}{(4\pi^3+\pi^2+\pi)\,r_e} = \frac{\alpha_e r}{r_e} \quad \textbf{(3.5.2)}$$

$$F_o = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r^2}\right)\left(\frac{r_e}{\alpha_e r}\right) \quad \textbf{(3.5.3)}$$

$$F_o = \mu_0 c^2 \left(\frac{r_e q_P^2}{4\pi\alpha_e r^3} \right) \qquad \textbf{(3.5.4)}$$

The equation above is the force of magnetism for a dipole, following the inverse cube law. In Section 5, it will be used to derive the Bohr radius using the form in Eq. 3.5.5, where the Planck charge is replaced with the elementary charge, using the relationship in Eq. 3.3.5. It is referred to later as the orbital force (F_o).

$$F_o = \mu_0 c^2 \left(\frac{r_e e_e^2}{4\pi\alpha_e^2 r^3} \right) \qquad \textbf{(3.5.5)}$$

3.6 The Gravitational Force

At the core of the particle, the motion of a center granule causes the spin of a particle. It was described in Section 3.3 to cause a loss in longitudinal wave energy, which is the electric force. For each electron, the motion of the center granule with cone radius of Planck length (l_P), and its effect on the electron at its surface (radius of r_e), can be described visually by the following:

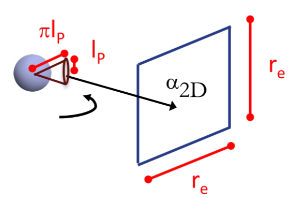


Fig. 3.6.1 – Geometry of a spinning granule and its effect on an electron (α_{2D})

Gravity will be shown to be a shading effect of two or more particles, similar to radiation pressure that causes a slight attraction between objects. It is a shading effect of the electric force, so the geometric ratio described in the figure above (α_{2D}) is appended to the equation for the electric force (from Eq. 3.3.1).

$$F_{Ge} = \frac{m_P c^2}{l_P} \left(\frac{\alpha_{1B}}{\alpha_{1A}} \right) (\alpha_{2B}) (\alpha_{2D}) \qquad \textbf{(3.6.1)}$$

The same geometry ratio (α_2) from Eq. 2.2.2 is used again but now with x and y variables set to Planck length (l_P). The result is then substituted into Eq. 3.6.1 and simplified.

$$\alpha_{2D} = \alpha_2 \{x = l_P, y = l_P, d = r_e, l = \pi r_e\} = \frac{l_P^2}{4\pi(\pi r_e)^2 + (\pi (r_e)(\pi r_e) + \pi r_e^2)} = \frac{l_P^2}{(4\pi^3 + \pi^2 + \pi) r_e^2} = \frac{\alpha_e l_P^2}{r_e^2} \qquad \textbf{(3.6.2)}$$

$$F_{Ge} = \frac{m_P c^2}{l_P} \left(\frac{4\pi l_P^2}{q_P^2} \right) \left(\frac{q_P^2}{4\pi r^2} \right) (\alpha_e) \left(\frac{\alpha_e l_P^2}{r_e^2} \right) \qquad \textbf{(3.6.3)}$$

$$F_{Ge} = \mu_0 c^2 \left(\frac{e_e^2}{4\pi r^2} \right) \left(\frac{\alpha_e l_P^2}{r_e^2} \right) \quad \textbf{(3.6.4)}$$

The result from Eq. 3.6.2 is recognized as the **gravitational coupling constant for the electron (α_{Ge})**, relative to the electric force. It is the numerical value for the gravitational coupling constant when expressed as a ratio between the force of gravity and the electric force *of two electrons* [10]. Note that the gravitational coupling of the proton (α_{Gp}) can be derived by multiplying the *square* of the proton-to-electron mass ratio to Eq. 3.6.4.

$$\alpha_{Ge} = \alpha_{2D} = \frac{\alpha_e l_P^2}{r_e^2} = 2.4 \cdot 10^{-43} \quad \textbf{(3.6.5)}$$

In Eq. 3.6.4, the force of gravity for the electron (F_{Ge}) can be seen as the electric force (the terms on the left match Eq. 3.3.6) with the gravitational coupling constant described in Eq. 3.6.5 on the right. The right term describes the energy loss from a second electron, as gravity is a shading effect between two electrons. This will be more apparent when described in Section 3.7. Putting Eq. 3.6.4 to the test, the force of two electrons is the following:

$$F_g = \mu_0 c^2 \left(\frac{e_e^2}{4\pi r_e^2} \right) \left(\frac{\alpha_e l_P^2}{r_e^2} \right) = 6.974 \cdot 10^{-42} \left(\frac{kg\,(m)}{s^2} \right) \quad \textbf{(3.6.6)}$$

However, most gravitational equations rely on mass (m), not charge, as variables. Using Newton's equation for gravity, it is found that the **mass of two electrons gives an identical result**, validating the equation here for gravity. The electron's mass (m_e) is 9.109×10^{-31} kg and the gravitational constant G is 6.6741×10^{-11} $m^3/kg\ s^2$.

$$F_g = \frac{G m_e m_e}{r_e^2} = 6.974 \cdot 10^{-42} \left(\frac{kg\,(m)}{s^2} \right) \quad \textbf{(3.6.7)}$$

The conversion from charge to mass and the derivation of the gravitational constant (G) as further proof of this equation will be shown in Section 5.8.

3.7 The Relationship of Forces

The conservation of energy and the transition of wave forms to be the cause of forces is easier to understand when measuring each force at the electron's classical radius. The relationship between all of the forces becomes clear. They are first expressed with equations and diagrams in table format (Table 3.7.1) and then described in detail.

The equations for the forces from Sections 3.2 to 3.6 are used in the table below and then distance r is set equal to the electron's classical radius (r_e) and simplified.

$$r = r_e \quad \textbf{(3.7.1)}$$

To simplify everything further, the common terms that exist in all equations are set to one (1). This allows the strong force to be proportionally set to one ($F \propto 1$) so that everything else is relative to this force. The following terms are set to one for the purpose of the simplified force (F) in the far-right column of the next table.

$$\left\{\left(\frac{m_P c^2}{l_P}\left(\frac{l_P^2}{r_e^2}\right) = 1\right)\right\} \tag{3.7.2}$$

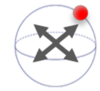
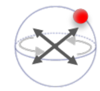
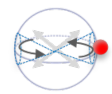
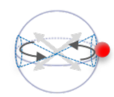
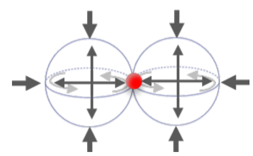
Strong	$F_s = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r_e^2}\right) = \frac{m_P c^2}{l_P}\left(\frac{l_P^2}{r_e^2}\right)$	 $F \propto 1$
Electric	$F_e = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r_e^2}\right)(\alpha_e) = \frac{m_P c^2}{l_P}\left(\frac{\alpha_e l_P^2}{r_e^2}\right)$	 $F \propto \alpha_e$
Magnetic (monopole)	$F_m = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r_e^2}\right)\left(\frac{1}{\alpha_e}\right) = \frac{m_P c^2}{l_P}\left(\frac{l_P^2}{\alpha_e r_e^2}\right)$	 $F \propto \frac{1}{\alpha_e}$
Magnetic (dipole)	$F_o = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r_e^2}\right)\left(\frac{r_e}{\alpha_e r_e}\right) = \frac{m_P c^2}{l_P}\left(\frac{l_P^2}{\alpha_e r_e^2}\right)$	 $F \propto \frac{1}{\alpha_e}$
Gravity	$F_{Ge} = \frac{m_P c^2}{l_P}\left(\frac{4\pi l_P^2}{q_P^2}\right)\left(\frac{q_P^2}{4\pi r_e^2}\right)(\alpha_e)\left(\frac{\alpha_e l_P^2}{r_e^2}\right) = \frac{m_P c^2}{l_P}\left(\frac{\alpha_e l_P^2}{r_e^2}\right)\left(\frac{\alpha_e l_P^2}{r_e^2}\right)$	 $F \propto \alpha_e\left(\frac{\alpha_e l_P^2}{r_e^2}\right)$

Table. 3.7.1 – The relationship of forces when measured at the electron's classical radius.
The red dot in the figures represents the point of force measurement.

The equations and accompanying figures depict the forces and their relationships as:

- **Strong Force** – The conservation of energy of in-waves as it is reflected as out-waves. When measured at the electron's classical radius, this is set to F ∝ 1 for readability to make other forces relative. *The conservation of energy was shown earlier in Sections 3.1 and 3.2.*

- **Electric Force** – The force of longitudinal out-waves in a particle like the electron where some energy is used for spin. It reduces longitudinal energy by a factor of the fine structure constant (α_e).

- **Magnetic Force (Monopole)** – The force of transverse out-waves in a particle like the electron, where additional energy from spin is added to longitudinal energy in a given direction (cone). It increases energy by a factor of the fine structure constant (α_e). Multiplying the ratios of the electric force and magnetic force returns back to one (α_e/α_e=1), identical to the strong force.

- **Magnetic Force (Dipole)** – At a distance of the electron's radius, the magnetic forces for monopoles and dipoles are identical. The dipole force is no longer the inverse cube. Similar to above, when multiplying by the ratio of the electric force, it returns back to one (α_e/α_e=1).

- **Gravity –** When the equation for gravity is expanded to its complete form and the electron's radius is used as the distance, note the two red circled terms in Table 3.7.1. They are identical to the circled term for the electric force. Each electron has a reduction of longitudinal (electric) energy due to spin, and this missing energy is accounted for in the magnetic force. But gravity is a shading effect that requires two or more particles. Thus, this energy loss appears twice to represent the loss of each electron in the equation. An illustration of the shading effect and gravitational constant (G) derivation is upcoming in Section 5.8.

4. Spacetime Modeled as a Spring-Mass System

The spacetime lattice of repeating bcc unit cells may be described as a spring-mass system and mathematically modeled with classical mechanics, even though it is not expected that spacetime literally includes *springs*. It is a representation of a unit cell with a center granule of Planck mass, with harmonic motion, affecting and displacing nearby granules in the lattice. Its harmonic motion produces a wave-like effect over time, where the distance from equilibrium over time is a sinusoidal wave, and the maximum displacement becomes the wave amplitude. At the center of a particle, it will be shown that this amplitude is Planck charge (q_P).

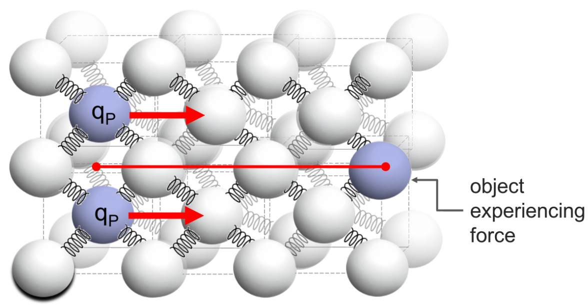


Fig. 4.1 – Spacetime as a spring-mass system

Displacement from equilibrium is the measurement of charge (q) and is a cumulative effect of interference. For (i) number of particles in the same phase, such as electrons, it is additive such that the constructive interference and calculation of charge is the addition of each individual charge (q_P), such that:

$$q = \sum_{1}^{i} q_P \tag{4.1}$$

At a granular level, each particle contains many granules that interact to cause the interference and presence of waves. Granules collide and transfer energy, producing waves and traveling through the spacetime lattice as wavelets according to Huygen's principle. The process of multiple granules in the same wave phase transferring energy can also be represented in the spring-mass system as parallel springs, where the force is additive [11].

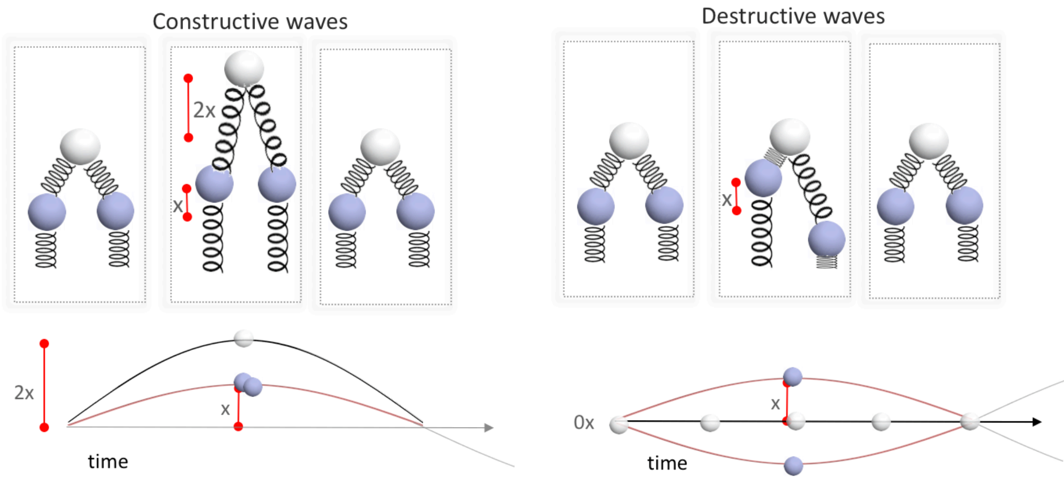


Fig. 4.2 – Constructive and destructive wave interference

The behavior of granules transferring energy will be constructive or destructive, depending on the direction of travel of nearby granules. In the same phase (traveling in same direction), amplitude is constructive as shown in the left of Fig. 4.2, and when in opposite phase (traveling in opposite directions), amplitude is destructive as shown on the right. This is equivalent to a spring system with parallel springs in which the spring constant (k) is additive ($k = k_1 + k_2$).

4.1 The Fundamental Frequency

For space and time to be intertwined as spacetime, the definition of time must be inherent in the geometry of the spacetime lattice itself. It is the harmonic motion of its components. In Fig. 4.1.1, the vibration of a granule is illustrated in blue in the left of the diagram as it completes one wavelength. On the right of the figure, it is compared to a granule traveling at a constant speed that travels a distance (l). This is the cone radius (d) and slant length (l) used earlier in Section 2.2.

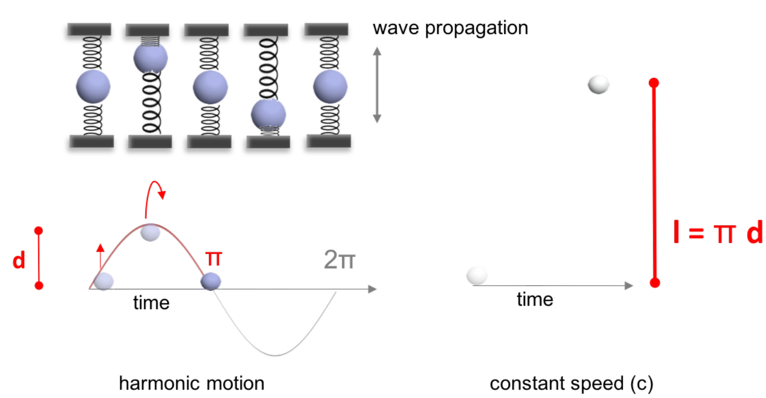


Fig. 4.1.1 – Harmonic motion of granule vibration creating a fundamental frequency

It becomes a fundamental frequency and a fundamental wavelength. The displacement of granules is in the same direction as wave propagation, becoming a longitudinal wave. Photons, which are transverse waves where vibration is perpendicular to wave propagation, will be addressed later in Section 5.

The fundamental frequency can be mathematically represented like the frequency in a spring-mass system. Eq. 4.1.1 represents the equation for the frequency of a spring with spring constant (k) and mass (m) [12].

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad \textbf{(4.1.1)}$$

A spring constant (k) can be determined by the force (F) divided by displacement (x). In the case of a unit cell, the fundamental force is the Coulomb constant (from Eq. 3.3.9) divided by the granule separation length (a) from Eq. 2.1. *Note that the spring constant (k) and Coulomb constant (k_e) have different units, even though both use the letter k.*

$$k = \frac{F}{x} = \frac{k_e}{a} \quad \textbf{(4.1.2)}$$

In a unit cell, the mass in the spring-mass system is a center granule of Planck mass (m_P). This mass is substituted into Eq. 4.1.1. The spring constant (k) from Eq. 4.1.2 is also substituted. The fundamental longitudinal frequency (f_l) and the fundamental longitudinal wavelength (λ_l) are calculated as:

$$f_l = \frac{1}{2\pi}\sqrt{\frac{k_e}{(a)\,m_P}} = 1.09107\cdot 10^{25}\left(\frac{1}{s}\right) \quad \textbf{(4.1.3)}$$

$$\lambda_l = \frac{c}{f_l} = 2.7477\cdot 10^{-17}\,(m) \quad \textbf{(4.1.4)}$$

The wavelength value matches the value derived a second way from Eq. 2.2 using Euler's number at 2.7 x 10^{-17} m. This value also sets a lower limit of the possible wavelengths of photons, as the transverse wave would not be able to exceed this longitudinal wavelength.

4.2 Energy of the Spring-Mass System

In a spring-mass system, energy is a function of displacement (x). In the context of a center granule in a spacetime unit cell, if the displacement is zero then there is no energy (despite having a mass of Planck mass). The energy (U) of a spring-mass system with spring constant (k) and displacement (x) is illustrated in the next figure and is described in Eq. 4.2.1.

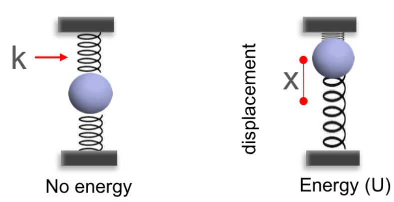


Fig. 4.2.1 – Energy of a spring-mass system for one-way displacement (x)

$$U = \frac{1}{2}kx^2 \quad \textbf{(4.2.1)}$$

The energy equations that follow will model the total energy (E) of a granule being displaced and returning to equilibrium. Thus, Eq. 4.2.1 is used twice as it completes an oscillation.

$$E = \frac{1}{2}kx^2 + \frac{1}{2}kx^2 \tag{4.2.2}$$

As found in Eq. 4.1.2, the spring constant (k) is the Coulomb constant (k_e) divided by the distance at which the force is applied. Now, the distance from the center of an electron will be set to a variable (r). The Coulomb constant is replaced in terms of the magnetic constant to complete Eq. 4.2.3. In Eq. 4.2.4, the displacement at the center of the particle is the Planck charge.

$$k = \frac{\mu_0 c^2}{4\pi}\left(\frac{1}{r}\right) \tag{4.2.3}$$

$$x = q_P \tag{4.2.4}$$

The two equations above are inserted back into the energy equation in Eq. 4.2.2 and labelled as a strong energy (E_s) in the next equation, as this is the energy of the strong force (F_s) derived back in Section 3.2. Force is energy over distance, so this equation could have simply been derived from the force equation. However, showing its origin from spring-mass equations will help to model and calculate the entire spacetime grid.

$$E_s = \frac{\mu_0 c^2}{4\pi}\left(\frac{q_P^2}{r}\right) \tag{4.2.5}$$

Similar to the transition from the strong force to electric force, the geometric ratio is applied from strong energy to electrical energy. The ratio (α_e) is applied for the electron in the next equation and simplified to use the elementary charge. This electrical energy is labelled (E_l) for longitudinal energy and will be used to calculate energies of particles, photons and orbitals as proof in the next Section 5.

$$E_l = \frac{\mu_0 c^2}{4\pi}\left(\frac{q_P^2}{r}\right)\alpha_e = \frac{\mu_0 c^2}{4\pi}\left(\frac{e_e^2}{r}\right) \tag{4.2.6}$$

5. Explaining the Universe's Fundamental Constants

The derivation of the upcoming energy and force equations are ultimately traced back to only five constants in Section 1 and two geometric ratios in Section 2. The magnetic constant, the fine structure constant, the Coulomb constant and the elementary charge constants used in this section are fundamental physical constants that are naturally derived in the process of explaining the conservation of energy as it changes in geometry and wave form.

Ten additional fundamental physical constants from physics equations are also derived from the base Planck unit system here, explaining why they appear in equations and offering further proof of this proposed geometry of spacetime. For example, Eq. 3.6.4 describes the gravitational force, which is well documented and known to be proportional to the gravitational constant (G) when mass and distance are used as variables. By deriving G, it is assumed that it is proof of the gravitational force equation found in Section 3. Or by deriving the Planck constant (h), it is assumed that it is proof of the energy equation found in Section 4.

This section includes derivations based on single electron interactions. As a result, no constructive or destructive wave interference is used or needed for the derivation of fundamental physical constants (Δ=1). However, for calculations of energies and forces of multiple particles, constructive interference should be assumed (Δ<>1). This is known to be the addition or subtraction of particles of charge (q) or mass (m).

5.1 Electron Energy & Mass

From the description of the energy of the spacetime lattice in Section 4 (Fig. 4.1), energy continually spreads from the center of the particle spherically, decreasing in granule amplitude (displacement) proportional to the distance from the center. Within a defined radius, this energy is measured as particle energy (or mass without c^2). Beyond this radius, energy continues but it is no longer considered to be within the confines of a particle. Its energy affects other particles, which is seen as the electric force (energy over distance).

It is the wave form that defines a particle and its boundary. When incoming waves of the same frequency meet outgoing waves of the same frequency, a phenomenon known as *standing waves* may occur. The outgoing waves created by each and every particle is traveling the spacetime lattice until reaching other particles, becoming in-waves for other particles. When this occurs, a standing wave forms near the center of the particle and spreads spherically outwards. A standing wave contains energy, but there is *no net propagation* of energy [13]. In other words, it is stored energy, which is why the volume contained in these standing waves appears as a spherical particle.

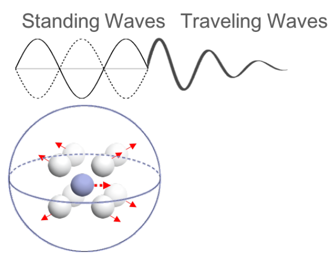


Fig. 5.1.1 – Electron energy and mass

For an electron, the transition point where standing waves become traveling waves and energy is no longer stored is at the electron's classical radius (r_e). The longitudinal energy equation from Eq. 4.2.6 is used to derive the electron's energy (E_e) and mass (m_e) in electrical constants, where the distance (r) is the edge of the standing waves - the electron's radius. The **electron's energy** is correctly calculated using this equation at the electron's radius in Eq. 5.1.1. And the **electron's mass** is the same equation without wave speed c^2, also correctly calculated.

$$E_e = \frac{\mu_0 c^2}{4\pi}\left(\frac{e_e^2}{r_e}\right) = 8.1871\cdot 10^{-14}\left(\frac{kg\,(m^2)}{s^2}\right) \quad \textbf{(5.1.1)}$$

$$m_e = \frac{\mu_0}{4\pi}\left(\frac{e_e^2}{r_e}\right) = 9.1094\cdot 10^{-31}\,(kg) \quad \textbf{(5.1.2)}$$

5.2 Bohr Radius

The energy of an electron continues beyond its radius, as derived in the electric force. When the force experiences constructive wave interference between an electron and a particle of the same wave phase (e.g. another electron), the particle motion is away from each other. When it experiences destructive wave interference with a particle of opposite wave phase (e.g. a positron) the particle motion is towards each other. In Fig. 5.2.1, an electron is attracted via the electric force (F_e) to a positively charged particle in the proton.

A proton is a known composite particle, containing at least three quarks (in some cases, five quarks have been found) [14]. It can be shown that an orbital force (F_o), also called the magnetic dipole force in Section 3.5, keeps the electron in orbit, forcing it out of the proton to balance the attractive force that pulls it in. The electron's orbit in an atom is where opposing forces are equal, illustrated in the next figure.

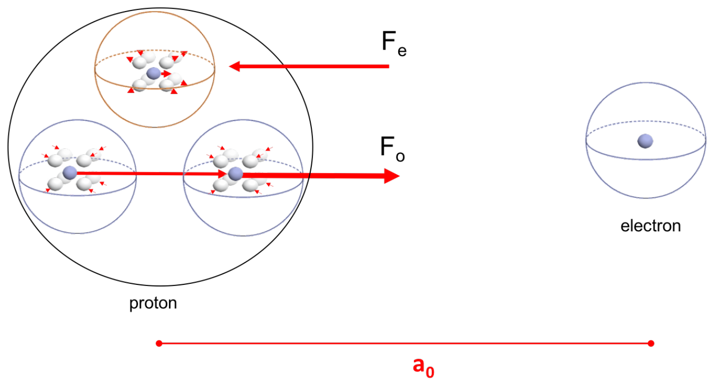


Fig. 5.2.1 – Single proton and electron (Bohr radius)

The electric forces and orbital forces are set to equal for the position where the forces on an electron is zero and it will be in a stable *orbit*. Eqs. 3.3.6 and 3.5.5 are substituted into Eq. 5.2.1 to solve for the forces.

$$F_e = F_o \quad \textbf{(5.2.1)}$$

$$\mu_0 c^2 \left(\frac{e_e^2}{4\pi r^2} \right) = \mu_0 c^2 \left(\frac{r_e e_e^2}{4\pi \alpha_e^2 r^3} \right) \quad \textbf{(5.2.2)}$$

After solving for r in Eq. 5.2.2, the distance is found to be the **Bohr radius** (a_0) – which is the most probable location of an electron in an orbit around a single proton (hydrogen).

$$r = \frac{r_e}{\alpha_e^2} \quad \textbf{(5.2.3)}$$

$$a_0 = \frac{r_e}{\alpha_e^2} = 5.2918 \cdot 10^{-11}\ (m) \quad \textbf{(5.2.4)}$$

5.3 Rydberg Unit of Energy

The energy between a single electron and proton can be solved now, knowing the Bohr radius as the distance between the two. This energy is known as the Rydberg unit of energy (E_{Ry}). The energy equation from Eq. 4.2.6 is used once again – the same equation used to calculate the electron's energy and the electric force.

In Fig. 5.2.1 above, the one-dimensional orbital force (F_o) is on an axis between the proton and electron. This force travels in both directions from the proton, eventually requiring an electron on the opposite side in an atom when more protons are added to balance the electric force. As a result, half of the energy is on the side between the proton and electron. A factor of ½ is applied to the longitudinal energy, as shown in Eq. 5.3.1. Then, Eq. 4.2.6 is substituted into Eq. 5.3.1 and the Bohr radius (a_0) is used as the distance r. It resolves correctly to be the **Rydberg unit of energy**.

$$E_{Ry} = \frac{1}{2} E_l \qquad \textbf{(5.3.1)}$$

$$E_{Ry} = \frac{1}{2} \frac{\mu_0 c^2}{4\pi} \left(\frac{e_e^2}{a_0} \right) = 2.1799 \cdot 10^{-18} \left(\frac{kg\,(m^2)}{s^2} \right) \qquad \textbf{(5.3.2)}$$

5.4 Avogadro's Constant

The energy between a single electron and proton is constant, as found in the Rydberg unit of energy. The mass contained in the unit cells that transfer this energy between the electron and proton is also constant. And the total number of unit cells will be shown to be equal to Avogadro's constant (N_A) – another constant.

In 1834, Michael Faraday found that the mass of a substance altered proportional to the charge in electrolysis, in what became known as Faraday's law of electrolysis – the Faraday constant is proportional to the elementary charge (e_e) and Avogadro's constant (N_A). It demonstrates that Avogadro's constant represents a number of something responsible for charge, which are unit cells between a proton and electron where the initial displacement is the elementary charge. Furthermore, since the proton and electron form the fundamental atom (hydrogen), and since all atoms and molecules are formed from a combination of protons and electrons, it would follow that Avogadro's constant would appear in other atoms with a greater number of protons, and also from molecules that are formed from such atoms.

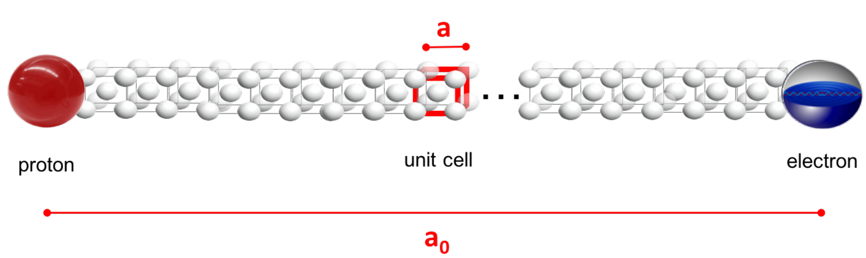


Fig. 5.4.1 – The number of unit cells between a single proton and electron – Avogadro's constant

The calculation of Avogadro's constant is found in Eq. 5.4.1. It is the probable distance between a single proton and electron (the Bohr radius, a_0, from Eq. 5.2.4), divided by the length of a spacetime unit cell (a, from Eq. 2.1). It resolves to be the total number of unit cells between the proton and electron – **Avogadro's constant**.

$$N_A = \frac{a_0}{a} = 6.022 \cdot 10^{23} \qquad (5.4.1)$$

5.5 Planck Constant

The Planck constant (h) is used in equations to describe photon energies, where energy is proportional to frequency (E=hf). A photon is a transverse wave, which is when the vibrating element moves perpendicular to wave propagation (unlike a longitudinal wave that is in the same direction of wave propagation).

Referring back to Fig. 5.2.1, the electron's position in a stable orbit is when the attractive electric force (F_e) and the repelling orbital force (F_o) are the same. When the electron is closer or further than this range, they are unequal, causing motion of the electron. While in motion, the granules at the center of the electron likely avoid the one-dimensional F_o force, since it repels along a defined axis. Yet, they should continue to be attracted to the F_e force, which is spherical, but the attraction is strongest when minimizing the distance between the particles. This causes a vibration of the granules within the center of the electron in the direction perpendicular to the line of the F_o force from the proton. Fig. 5.5.1 describes this vibration (illustrated as up-down in the figure), creating a transverse wave. It now has a two-dimensional vibration while the electron is in motion as it continues to respond to incoming waves, oscillating a distance of Planck charge (q_P).

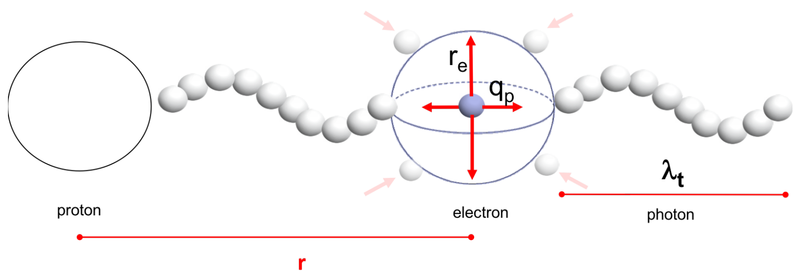


Fig. 5.5.1 – Generation of a photon as a transverse wave

The transverse wave energy (E_t) is a conservation of energy. It can be described mathematically as the electrical force (F_e) at a distance (r) between the proton and electron. As there are two transverse waves on each side of the particle, the energy measured on one side is half the value, expressed in the next equation.

$$E_t = \frac{1}{2} F_e (r) \qquad (5.5.1)$$

Substitute for the electric force (F_e) from Eq. 3.3.6 and then rearrange terms.

$$E_t = \frac{1}{2} \mu_0 c^2 \left(\frac{\alpha_e q_P^2}{4\pi r^2} \right) (r) \qquad (5.5.2)$$

$$E_t = \frac{1}{2} \mu_0 c q_P^2 \left(\frac{\alpha_e c}{4\pi r} \right) \qquad (5.5.3)$$

The **Planck constant** (h) is a proportionality constant representing the constants in the left, outside of the parentheses, in Eq. 5.5.3. The remainder is used in the next section on frequency.

$$h = \frac{1}{2}\mu_0 c q_P^2 = 6.6261 \cdot 10^{-34} \left(\frac{kg\,(m^2)}{s} \right) \tag{5.5.4}$$

5.6 Rydberg Constant

Eq. 5.5.2 expresses the Planck relation (E=hf) in terms all derived from the original four Planck units and the electron's classical radius from Section 1. While the constants that constitute the Planck proportionality constant are on the left, the remaining variables and constants within parentheses are frequency. For a single proton and electron, the distance (r) is the Bohr radius (a_0). Inserting this distance into Eq. 5.5.3 yields the transverse wave frequency for a photon at ground state hydrogen.

$$f_0 = \frac{\alpha_e c}{4\pi a_0} = 3.29 \cdot 10^{15} \left(\frac{1}{s} \right) \tag{5.6.1}$$

This frequency is more commonly expressed as the **Rydberg constant** (R_∞), which is found by removing wave speed (c) from Eq. 5.6.1 such that it becomes an inverse of wavelength:

$$R_\infty = \frac{\alpha_e}{4\pi a_0} = 1.097 \cdot 10^7 \left(\frac{1}{m} \right) \tag{5.6.2}$$

This section derives fundamental physical constants with only single particle interaction (one electron or one proton), ignoring constructive wave interference. Calculating the frequency of atoms with multiple protons does indeed require constructive wave interference (Δ), which results in two variables in the frequency equation (wave interference and distance). The complete equation for frequency is found below, and has been validated by calculating energies and frequencies of photons from hydrogen to calcium in a separate paper [15].

$$f = \frac{\Delta \alpha_e c}{4\pi r} \tag{5.6.3}$$

5.7 Compton Wavelength

The Compton wavelength (λ_C) occurs when photon energy is equal to a particle's rest energy, found in annihilation when an electron and positron annihilate. Eq. 5.6.3 can be used to find this frequency and wavelength. It describes the interaction between single particles (Δ=1). The only remaining variable is the distance at which the particles rest and are stable (r).

From the description of the electron in Section 5.1, standing waves occur within the electron's radius (r_e). From the description of destructive waves in Section 4, it is assumed that the position halfway between the electron's standing wave radius is the position in which the net amplitude of all granules within the particles is zero. In other words, it is completely destructive at half the electron's radius ($r_e/2$), providing a position for stability of the particles where no longitudinal waves emerge because of their destructive properties. This distance is substituted into Eq. 5.6.3 as shown below to resolve for frequency in Eq. 5.7.1.

Then, the Compton wavelength is solved by using the relationship of frequency and wavelength by taking the inverse and removing wave speed (c). This results in the calculation of the **Compton wavelength** in Eq. 5.7.2.

$$f_C = \frac{\alpha_e c}{4\pi \frac{r_e}{2}} = \frac{\alpha_e c}{2\pi r_e} \tag{5.7.1}$$

$$\lambda_C = \frac{c}{f_C} = \frac{2\pi r_e}{\alpha_e} = 2.426 \cdot 10^{-12}\,(m) \tag{5.7.2}$$

5.8 Gravitational Constant

The gravitational constant (G) is used in the calculation of gravitational forces when the masses of two objects are used as variables. Mass is a collection of a number of particles, including the electron, all of which experience gravity. Thus, at the lowest level, the gravitational constant should appear in single particle interaction even if other forces dominate at this level (the electric force is significantly stronger for two electrons than gravity, repelling them instead of attracting them).

From the explanation of the geometry of gravity in Section 3, a single electron particle is now expanded to illustrate two particles and a shading effect between the particles. In the figure, each electron has incoming wave amplitude at the surface of the sphere that is greater than the outgoing wave amplitude at the surface of the sphere as a result of transferring some energy to motion at the electron's core (causing spin). Ignoring other forces (i.e. the electric force), it would cause an attraction of the particles due to a net force as a result of unequal energy on the opposite sides of the particles. This causes a shading effect between the particles.

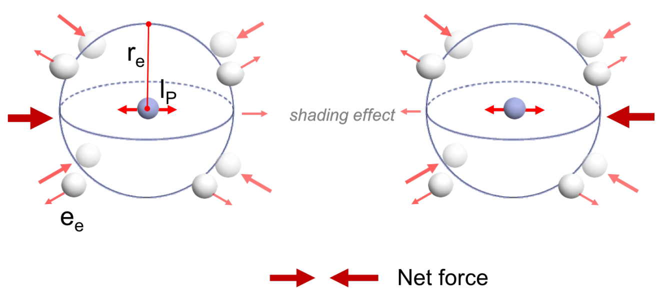


Fig. 5.8.1 – Two particles and a net force forcing particles together as a result of an energy shading effect

The equation to model two electrons begins with the gravitational force equation from Eq. 3.6.4, shown again in the next equation labelled as F_g.

$$F_g = \mu_0 c^2 \left(\frac{e_e^2}{4\pi r^2} \right) \left(\frac{\alpha_e l_P^2}{r_e^2} \right) \quad \textbf{(5.8.1)}$$

The issue is that the gravitational constant (G) assumes a measurement in mass (m), not the elementary charge (e_e). However, mass and charge are related and were described earlier in Section 5.1. Total mass will eventually be described in equations as a summation of the constructive wave interference of many particles. For single particles, the mass of one electron in terms of electrical constants comes from Eq. 5.1.2 and is shown again below. Then, ***one*** elementary charge is isolated in Eq. 5.8.3.

$$m_e = \frac{\mu_0}{4\pi} \left(\frac{e_e^2}{r_e} \right) \quad \textbf{(5.8.2)}$$

$$e_e = \frac{m_e 4\pi r_e}{\mu_0 e_e} \quad \textbf{(5.8.3)}$$

Substitute Eq. 5.8.3 into 5.8.1 and simplify.

$$F_g = \frac{\mu_0 c^2}{4\pi} \left(\frac{\left(\frac{m_e 4\pi r_e}{\mu_0 e_e} \right)^2}{r^2} \right) \left(\frac{\alpha_e l_P^2}{r_e^2} \right) \quad \textbf{(5.8.4)}$$

$$F_g = \frac{4\pi \alpha_e c^2 l_P^2}{\mu_0 e_e^2} \left(\frac{m_e^2}{r^2} \right) \quad \textbf{(5.8.5)}$$

The elementary charge in the denominator and the fine structure constant in the numerator can be replaced to convert back to Planck charge, per the relationship in Eq. 3.3.5. It can be further reduced by converting the magnetic constant back to original Planck constants, per Eq. 3.1.5. These substitutions greatly reduce the equation for gravitation.

$$F_g = \frac{4\pi \left(\frac{e_e^2}{q_P^2} \right) c^2 l_P^2}{\frac{m_P}{l_P} \left(\frac{4\pi l_P^2}{q_P^2} \right) e_e^2} \left(\frac{m_e^2}{r^2} \right) \quad \textbf{(5.8.6)}$$

$$F_g = \frac{l_P c^2}{m_P} \left(\frac{m_e^2}{r^2} \right) \quad \textbf{(5.8.7)}$$

The constants on the left of Eq. 5.8.7 are the **gravitational constant (G),** as calculated correctly in both value and units. It demonstrates that gravity occurs at a single particle, and its force will be proportional to mass due to constructive wave interference, as mass is the additive interference of multiple particles.

$$G = \frac{l_P c^2}{m_P} = 6.674 \cdot 10^{-11} \left(\frac{m^3}{kg\,(s^2)} \right) \quad \textbf{(5.8.8)}$$

5.9 Bohr Magneton

The Bohr magneton (μ_B) represents the electron's magnetic moment, described earlier in Section 3 on the magnetic force of a monopole. In the gravitational explanation of two electrons in Fig. 5.8.1, the wave amplitude and energy coming into the surface of the electron's sphere is not equal to its outgoing amplitude and energy. The difference is very slight as a result of the motion of a center granule being displaced a Planck length. Due to the conservation of energy principle, there should be energy transferred as a result of this center granule motion. This is illustrated in the next figure.

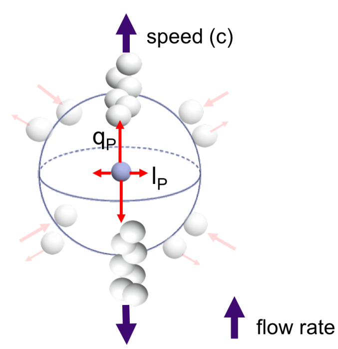


Fig. 5.9.1 – Flow rate of granules at two poles of a particle

Fig 5.9.1 shows the energy from this vibration flowing through the electron at two poles. But the Bohr magneton is not expressed in terms of either energy nor force. In the simplified kg/m/s unit system from Section 1, the Bohr magneton's units resolve to cubic meters per second (m^3/s) when the units of charge (Coulombs) are replaced with the units of distance (meters). These units make the Bohr magneton the equivalent of a flow rate, calculating the flow from one pole of the electron.

The derivation begins with the magnetic force (monopole) from Eq. 3.4.3. This equation is slightly modified to insert the square of the electron's classical radius in both the numerator and denominator, which is the original derivation of the fine structure constant back in Eq. 2.2.4. Next, in Eq. 5.9.2, Planck charge is replaced with the elementary charge, by inserting another fine structure constant in the denominator (the relationship per Eq. 3.3.5).

$$F_m = \mu_0 c^2 \left(\frac{q_P^2}{4\pi r^2} \right) \left(\frac{r_e^2}{\alpha_e r_e^2} \right) \quad \textbf{(5.9.1)}$$

$$F_m = \mu_0 c^2 \left(\frac{e_e^2}{4\pi r^2}\right)\left(\frac{r_e^2}{\alpha_e^2 r_e^2}\right) \quad \textbf{(5.9.2)}$$

The Bohr magneton volume flow is a measurement at the electron's surface, so the radius (r) is set to the electron's classical radius (r_e). This is simplified and rearranged in the next equation.

$$F_m = \left(\frac{c^2 e_e^2 r_e^2}{4\alpha_e^2}\right)\frac{\mu_0}{r_e^2}\frac{1}{\pi r_e^2} \quad \textbf{(5.9.3)}$$

Rearranging in this format allows the force to be expressed in terms of the flow rate (squared), through the electron's cross section (surface area – S_e) of a given density (ρ). This simplified format is expressed as:

$$F_m = \frac{\mu_B^2 \rho}{S_e} \quad \textbf{(5.9.4)}$$

The surface area of the electron's cross section is:

$$S_e = \pi r_e^2 \quad \textbf{(5.9.5)}$$

The magnetic constant was described earlier in Section 3.1 as a linear density. To make it a volumetric density for the electron, it is the magnetic constant divided by the electron's radius squared (r_e^2) to give it complete density units of kg/m^3.

$$\rho = \frac{\mu_0}{r_e^2} \quad \textbf{(5.9.6)}$$

Eq. 5.9.4 was arranged to show the density and surface area properties on the right side of the equation. The remaining constants in parentheses in that equation make up the flow rate. This is the square of the Bohr magneton. Taking the square root of this leads to the derivation of the **Bohr magneton** derived from the magnetic force equation.

$$\mu_B^2 = \frac{c^2 e_e^2 r_e^2}{4\alpha_e^2} \quad \textbf{(5.9.7)}$$

$$\mu_B = \frac{c e_e r_e}{2\alpha_e} = 9.274 \cdot 10^{-24}\left(\frac{m^3}{s}\right) \quad \textbf{(5.9.8)}$$

Conclusion

The structure of spacetime was found to be similar in equation to a spring-mass system, allowing all calculations of energy and forces to be based on classical mechanics and properties where the components of the spacetime unit cell have a known position in time and space.

A ratio of geometric shapes, including a rectangle, sphere and cone were found to be important in this paper. The strong force used a ratio of the surface area of a rectangle compared to the surface area of a sphere. Then, adding the surface area of a cone to the sphere provided the unification of forces as the coupling constants for the electric force, gravitational force and magnetic forces – all of which were the same geometry yet differed in variables for the lengths and widths of the geometries.

The simplified unit system with three basic units (kg, m, s) and only five constants (Planck length, Planck mass, Planck time, Planck charge and the electron's classical radius) were used along with the geometry ratios established for forces and correctly derived and calculated more than a dozen fundamental physical constants associated with the electron. It includes proportionality constants such as the gravitational constant (G), the Planck constant (h) and the Rydberg constant (R_∞) which have been validated in physics equations across a wide range of measurements for gravitational forces, photon energies and photon wavelengths respectively, thus validating the simplified equations in this paper.

---

[1] Disalle, R., 2006. Understanding Space-Time: The Philosophical Development of Physics from Newton to Einstein. *Cambridge University Press*, Cambridge, UK.

[2] Kisak, P., 2015. Planck Units: The Fundamental Units of our Universe. *CreateSpace*.

[3] Yee, J., Gardi, L., 2019. The Relationship of Mass and Charge. *ResearchGate*. Online: https://www.researchgate.net/publication/332083618.

[4] Yee, J., 2019. The Relationship of the Mole and Charge. *ResearchGate*. Online: https://www.researchgate.net/publication/332603438.

[5] Yee, J., 2019. The Relationship of the Fine Structure Constant and Pi. *ResearchGate*. Online: https://www.researchgate.net/publication/333224718.

[6] Lewis, G., Barnes, L., 2016. A Fortunate Universe: Life in a Finely Tuned Cosmos. *Cambridge University Press*, Cambridge, UK.

[7] Mohr, P., Newell, D. and Taylor, B., 2014. CODATA Recommended Values of the Fundamental Physical Constants, *Rev. Mod. Phys. 88*, 035009.

[8] Huygens, C., 1690. *Traité de la Lumière*, translated by Silvanus P. Thompson as Treatise on Light (Macmillan, London, 1912).

[9] Yee, J., Gardi, L., 2019. The Geometry of Particles and the Explanation of Their Creation and Decay. *ResearchGate*. Online: https://www.researchgate.net/publication/335101008_The_Geometry_of_Particles_and_the_Explanation_of_their_Creation_and_Decay

[10] Fermilab, 2019. Physics Questions People Ask Fermilab. Online: https://www.fnal.gov/pub/science/inquiring/questions/strong_force.html.

[11] Davis, J., 2000. Mathematics of Wave Propagation. *Princeton University Press,* Princeton, NJ.

[12] Hyperphysics, 2019. Simple Harmonic Motion Frequency. Online: http://hyperphysics.phy-astr.gsu.edu/hbase/shm2.html.

[13] Wikipedia, 2019. Standing Wave. Online: https://en.wikipedia.org/wiki/Standing_wave.

[14] CERN, 2015. CERN's LHCb experiment reports observation of exotic pentaquark particle. *Cern.com*. Online: http://press.cern/press-releases/2015/07/cerns-lhcb-experiment-reports-observation-exotic-pentaquark-particles.

[15] Yee, J., 2018. Atomic Orbitals: Explained and Derived with Energy Wave Equations, *Vixra.org,* 1708.0146.