The Physics of Subatomic Particles and their Behavior Modeled with Classical Laws

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Abstract: Using the physics of sound waves as a foundation, subatomic particles and their behaviors are modeled with classical mechanics to calculate the Planck energy, the electron's energy and the energy levels of the first two atoms: hydrogen and helium. Five different methods are used to calculate energies, including spring-mass systems and wave systems, and all five are found to be equal in their calculations.

Summary of Results

Energies of particles and atoms are calculated using five methods to demonstrate that the laws of classical mechanics can be applied to subatomic particles. The following methods, each with its own section in this paper detailing its equations, are used to calculate energy values found in Table 1:

1. Planck Energy Ratio – A ratio of energy decreasing from a center object of Planck mass and radius of Planck length
2. Spring (1D) – The energy of a spring-mass system with a single mass in one dimension
3. Spring (1D Series) – The energy of multiple masses connected in series in a spring-mass system in one dimension
4. Wave (1D) – The energy of a wave in one dimension
5. Wave (3D) – The energy of a wave calculated spherically from a center in three dimensions

Energy values for each method were calculated at four distances, including a hypothetical particle with radius of Planck length, the electron particle using the electron's classical radius and two atoms: hydrogen and helium. Energy (E) values found in this table, and throughout this paper are measured in joules (kg * m^2/s^2). All other units are specified in their respective equations. The values and units for all constants in this paper are found in the Appendix.

	Planck Energy Ratio	Spring (1D)	Spring (1D Series)	Wave (1D)	Wave (3D)
Planck length	1.96×10^{9}	1.96×10^{9}	1.96×10^{9}	1.96×10^{9}	N/A
Electron radius[a]	8.19×10^{-14}	8.19×10^{-14}	8.19×10^{-14}	8.19×10^{-14}	8.19×10^{-14}
Hydrogen radius[a,b]	4.36×10^{-18}	4.36×10^{-18}	4.36×10^{-18}	4.36×10^{-18}	4.36×10^{-18}
Helium radius[a,b]	7.69×10^{-18}	7.69×10^{-18}	7.69×10^{-18}	7.69×10^{-18}	7.69×10^{-18}

[a] – Energy based on electron uses elementary charge amplitude (square of Planck charge and fine structure constant)
[b] – Energy of atom at radius from nucleus; photon energy is half of the value

Table 1 – Calculated energies at various distances using classical equations. All calculations in joules (kg*m^2/s^2).

The energy values using each method were found to be equal. The energy at the Planck length is found to be the Planck energy (1.96×10^{9} joules) [1]. The energy at the electron's radius is found to be the electron's known rest energy (8.19×10^{-14} joules). The energy for hydrogen is found to be the Hartree energy (4.36×10^{-18} joules). And the energies for hydrogen and helium atoms are the Coulomb energies at a distance, which can be derived as a force between two particles. Note that the energy values for hydrogen and helium are exactly twice the energy of their photons. Specifically, the photon energy in hydrogen 1s ionization is 2.18 x 10^{-18} joules (half of 4.36 x 10^{-18}), and for helium 1s ionization it is 2.3 MJ/mol, or 3.8 x 10^{-18} joules (half of 7.69 x 10^{-18}).

In Table 1, one calculation was not possible. The method used to derive the energy values using the equations in Section 5, Wave (3D), is based on the electron and not used to calculate the Planck energy. It is listed as N/A.

It is not surprising that these equations for various spring-mass systems and waves are equivalent. In fact, the energy of sound can be modeled as the conservation of energy of a loudspeaker vibrating as a spring-mass system, creating sound waves in air. There are known classical mechanics equations to model the behavior of sound energy. What is surprising, however, is that these same equations have not been applied to subatomic particles and their behavior.

The Physics of Air and Sound

The behavior of subatomic particles begins with a review of the physics of sound, within air, which can be calculated using classical mechanics [2]. Since it will be shown that subatomic particles can be modeled with the same equations, the sizes of air molecules and distances between molecules have been adjusted to values at the subatomic scale. For clarity, this paper does not suggest air molecules fill the vacuum of space – it is only used to illustrate the similarities of the physics of wave behavior in molecules and the wave behavior in subatomic particles.

First, imagine a sphere of air with a radius of the Bohr radius (a_0), which is referred to in this paper as r_h, for the radius of hydrogen. This sphere of air has a known density (ρ). Each air molecule has a radius of Planck length (l_P), equally spaced apart with no motion, as shown in Fig. 1. If energy is a measurement of sound energy – the motion of air molecules – then the sphere in Fig. 1 would be considered to have no energy.

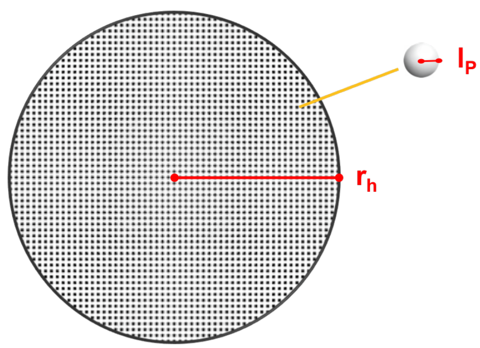


Fig. 1 – A sphere of air molecules (*with adjusted properties for size)*

Next, imagine a speaker is placed in the center of this sphere, creating sound waves as described in the next figure. The vibrational motion of air molecules creates longitudinal wave patterns which are sound waves, with a defined wavelength (λ) and an amplitude (A) that decreases with distance as molecules spread energy to a greater number of molecules when waves spread spherically from the center. Now, if sound energy is considered as the measurement of energy, then the sphere is considered to have energy. Sound exists and it can be detected by measuring tools.

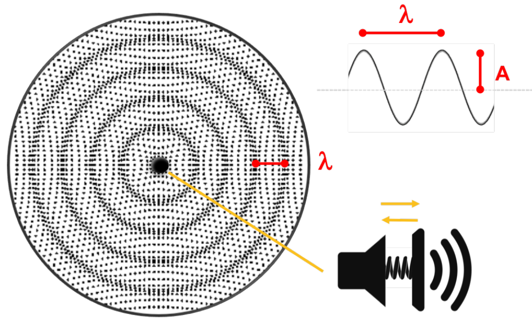


Fig. 2 – Sound moving through air as longitudinal waves with amplitude (A) and wavelength (λ).

Wave equations can be used to calculate sound energy, but due to the conservation of energy rule, it becomes simple to determine the energy of sound waves from the source that produced them. The speaker in the center of Fig. 2 that produces sound vibrates as a spring-mass system as the diaphragm expands and contracts to move air molecules. The potential energy of a spring is $U=\frac{1}{2}kx^2$, where k is the spring constant and x is the displacement. In this case, the maximum displacement is the amplitude, so x is assigned the letter (A) for maximum amplitude. The total energy (E) is calculated for a diaphragm that expands and contracts, returning to equilibrium, so E=2U. This becomes the equation to calculate the energy produced by the speaker:

$$E = kA^2 \tag{1}$$

Now, imagine that the phenomenon known as standing waves occurs near the center of the sphere, but does not occur throughout the entire sphere. These standing, longitudinal waves are composed of vibrating air molecules creating sound, as wave motion in opposite directions are equal such that there is *no net propagation* of energy within the volume [3]. It is considered to be stored energy within this spherical volume of standing waves, where the volume has a defined radius at the edge of standing waves of length r_e (for the electron's classical radius).

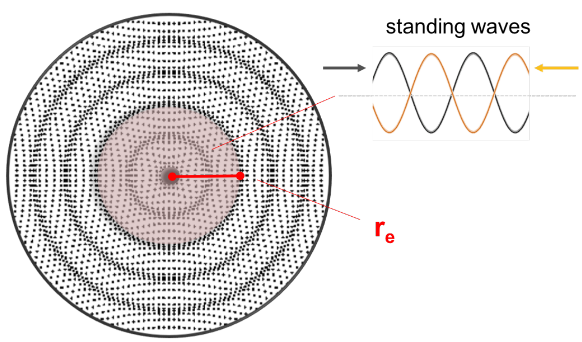


Fig. 3 – Standing waves at the center of a sphere (highlighted red) to a distance of r_e.

This is the physics of sound. Energy exists within the entire sphere, but how does one know that it contains energy? Imagine three different types of experiments to measure this energy, or what can be derived from energy, at three points described in the next figure as: 1) motion, 2) light and 3) weight.

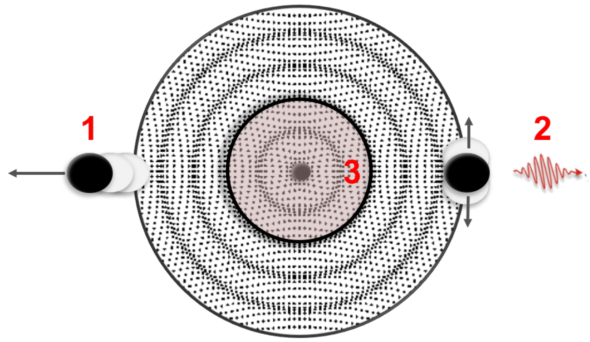


Fig. 4 – Measuring energy within the sphere using three methods: 1) motion, 2) light and 3) weight.

The first experiment for motion from sound is straightforward. An object, such as a ping pong ball, can be placed at a distance from the speaker and the force on that object can be calculated based on its acceleration. Energy is force over a distance (E=Fr), thus energy can be determined knowing the force and distance from the source. Its energy is found to be greater as amplitude increases or distance decreases.

The second experiment is not as common, but exists in special cases when sound produces light in a process referred to as sonoluminescence, where a small bubble is acoustically suspended and vibrated at given sound wave frequencies to create light [4]. Light is energy. Its energy, which will be detailed in Section 3, is found to be greater as its frequency increases (E=hf).

The third experiment is more difficult for sound, but will be shown to occur for particles. Imagine that stored energy within standing waves is contained in a volume like a balloon, such that an external force like gravity is applied to determine its energy through measurements like mass and weight. Its energy is found as the relation between mass and wave speed ($E=mc^2$).

The Physics of Sound with No Air

Sound is possible because of the motion of air molecules. It has a medium for sound waves to propagate. Nevertheless, imagine a scenario where energies and forces from the three previous experiments needed to be calculated and their results explained without air molecules. No air. Because human eyes cannot see air molecules, they are deemed to not exist in this implausible scenario, yet it is still possible to perform calculations and explain the experiments.

To explain the physics of sound with no air in the previous example of a sphere with Bohr radius (r_h), all air molecules are collapsed to be a single molecule in the center of the sphere. To do this, the total number of molecules and the mass of each one is determined before collapsing to a single mass. From a separate paper on the *Geometry of Spacetime and the Unification of Forces*, a structure of *granules* was proposed due to the relationship of Planck length and Avogadro's number in hydrogen [5]. The total number (N) and mass (m_g) proposed below can be derived from this relationship, but the importance of these numbers for this paper is not as significant as the density property. The total number and mass may vary as long as density is maintained.

- m_g – granule mass (1.18936×10^{-80} kg)
- N – number granules in hydrogen sphere (1.82995×10^{72})

In this scenario, and for illustration only, the number of air molecules from Fig. 1 is assumed to be N, the mass of each air molecule is m_g and the radius of each air molecule is l_P. All molecules are collapsed to be a single molecule, still maintaining the same Planck length (l_P) size, but now with a significantly higher mass (m_P). As a result, only empty space surrounds the sphere not occupied by the single mass at its center.

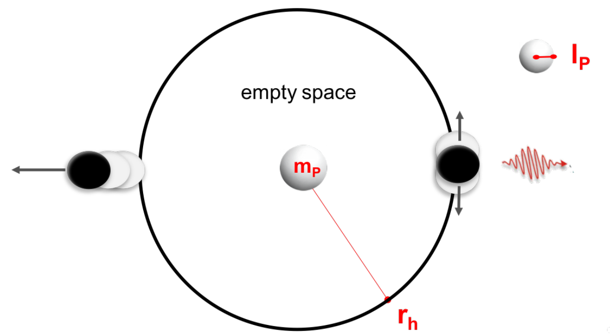


Fig. 5 – An empty sphere with only a single mass at the center of m_P and radius l_P affecting nearby particles.

After collapsing all mass to the center, the mass of the single air molecule is Planck mass (m_P) – 2.1768 x 10^{-8} kg.

$$m_P = Nm_g = 2.1768 \cdot 10^{-8} \; [kg] \qquad \textbf{(2)}$$

It is the density property that is important for maintaining calculations for sound waves in air, and also for a single mass with no air. Adding the collective mass of all air molecules or a single mass at the center is the same. The density of the Planck mass within this spherical volume of Bohr radius (hydrogen) is a very dense 4 x 10^{22} kg/m^3.

$$\rho = \frac{m_P}{V_h} = \frac{m_P}{\frac{4}{3}\pi r_h^3} = 4 \cdot 10^{22} \left[\frac{kg}{m^3} \right] \qquad \textbf{(3)}$$

In the next sections, the physics of sound is applied to subatomic particles, where the same equations can be used to describe sound *without* any air molecules for waves. Or, they can be used to describe energies of particles as waves *within* a medium in what is currently considered to be empty space. Both scenarios, while seemingly strange, can be shown to be the same physics and that their energies are equal.

1. The Physics of Particles and the Planck Energy Ratio

The first of five methods used to calculate energies is a single mass at the center of a sphere, radiating energy throughout empty space, measured by objects at defined distances. In the previous example, air molecules collapse to a single molecule of Planck mass (m_P) and a radius of Planck length (l_P). The energy of this mass is known as the Planck energy (E_P), 1.96 x 10^9 joules.

$$E_P = m_P c^2 = 1.96 \cdot 10^9 \qquad \textbf{(1.1)}$$

Energy radiates from the single molecule, declining at a distance r from the center as described in the next figure.

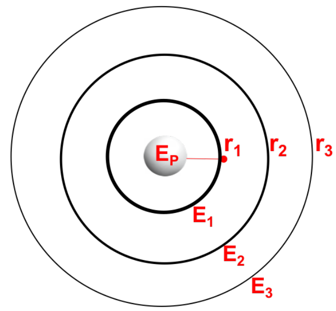


Fig. 6 – Planck energy (E_P) radiating from the center of a sphere, decreasing energy (E_x) at each measured distance (r_x)

Although there is no explanation for how this energy radiates spherically from the center, it can be calculated with a simple equation using the Planck energy (E_P), and a ratio of the center object's radius (l_P) and measured distance (r).

$$E = E_P\left(\frac{l_P}{r}\right) \quad \textbf{(1.2)}$$

Eq. 1.2 will be used to demonstrate energies of particles and atoms found in Table 1. Like a sound wave traveling in space without air, the same is believed of subatomic particles and their forces traveling in the vacuum of space without a medium.

First, a note about all calculations that are based on the electron particle in this paper. Due to the spin of the electron, some longitudinal wave energy is lost because it is used for spin. All energy calculations for the electron (E_x) are reduced by a factor of the fine structure constant (α_e), as expressed in the next equation.

$$E_x = E_P\left(\frac{l_P}{r}\right)\alpha_e \quad \textbf{(1.3)}$$

Energy is now calculated using the Planck energy ratio method for the four distances found in Table 1. The first calculation (E_{lP}) uses the ratio from Eq. 1.2, resulting in the Planck energy. The remaining calculations are based on the electron and use the ratio from Eq. 1.3, resulting in the calculations for the electron's rest energy (E_e), the energy at the Bohr radius of hydrogen (E_h) and the energy at the 1s orbital distance of helium (E_{he}).

$$E_{lp} = E_P\left(\frac{l_P}{l_P}\right) = 1.96\cdot 10^{9} \quad \textbf{(1.4)}$$

$$E_e = E_P\left(\frac{l_P}{r_e}\right)\alpha_e = 8.19\cdot 10^{-14} \quad \textbf{(1.5)}$$

$$E_h = E_P\left(\frac{l_P}{r_h}\right)\alpha_e = 4.36\cdot 10^{-18} \quad \textbf{(1.6)}$$

$$E_{he} = E_P\left(\frac{l_P}{r_{he}}\right)\alpha_e = 7.69\cdot 10^{-18} \quad \textbf{(1.7)}$$

As explained in the Summary of Results, the energy values for hydrogen and helium are twice the energies of the photons found in their ionization. This can be explained by the fact that there are two electrons per lobe in the atom to complete its energy. Beyond helium, this method can be used, but elements beginning with lithium have additional electrons at various distances from the nucleus that need to be considered. A separate paper on *Atomic Orbitals* lays out the framework to calculate elements with two or more orbitals [6]. But the principle remains the same and the energies of photons can be calculated with classical mechanics.

2. Spring-Mass Energy (1D – Single Mass)

Although the method in the previous section calculates the Planck energy, the electron's energy and the energies for the first two elements at their first orbital, it provides no explanation as to how this energy propagates. For example, if the experiment was measuring sound energy propagating from the speaker at the center of the sphere, able to move a ping pong ball at a Bohr radius distance from the center, one would question how the ping pong ball moved if there was only empty space – no air.

A solution to this problem is the motion of the center mass. In the next figure, the center mass of Planck mass (m_P) is shown to vibrate from the center, colliding with the object at a distance r. If it vibrates and returns to its initial position, then its harmonic motion can be modeled like a spring-mass system [7].

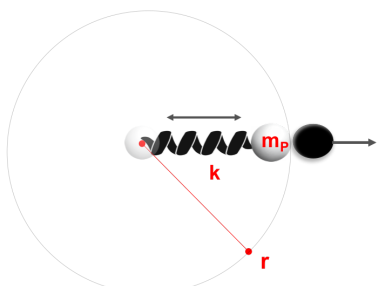


Fig. 7 – Spring-mass system of a single mass (m_P) and a spring constant k.

As explained earlier, the potential energy (U) is ½kx² for the spring-mass, where the max displacement amplitude is A, and the energy value is twice the potential energy as it expands and then contracts to equilibrium. Eq. 1 is shown again in Eq. 2.1. In a spring-mass system, the spring constant (k) is calculated as force (F) divided by distance (r).

$$E = kA^2 \qquad \textbf{(2.1)}$$

$$k = \frac{F}{r} \qquad \textbf{(2.2)}$$

The force in the spring constant is already known and was found by Charles-Augustin de Coulomb and is now called Coulomb's constant (k_e). What Coulomb found is the property of an electric universe that exists between particles, and can also be represented in a spring-mass system as the spring constant (k) when this force is divided by distance (Eq. 2.3). *Note that despite using the same letter "k", the units for the spring constant (k) and Coulomb's constant (k_e) are different.*

$$k = \frac{k_e}{r} \tag{2.3}$$

$$E = k_e\left(\frac{A^2}{r}\right) \tag{2.4}$$

Substituting Eq. 2.3 into 2.1 yields the energy equation in Eq. 2.4 – the equation that is used to determine the energy of a one-dimensional spring-mass system for the second method. For a single particle, wave amplitude (A) is the Planck charge (q_P), which is the maximum displacement distance of the mass. Therefore, Planck charge in SI units is meters.

Eq. 2.4 is used for all four distances found in Table 1, and once again the values are found to be identical. The Planck energy (E_{lP}) is found in Eq. 2.5 and the electron's energy is found in Eq. 2.6. Note that the fine structure constant is applied again to the amplitude for electron-based calculations. The energies for hydrogen and helium use an identical method as the electron's energy, with exception of distance (r), and are not repeated.

$$E_{lp} = k_e\left(\frac{q_P^2}{l_P}\right) = 1.96\cdot10^{9} \tag{2.5}$$

$$E_e = k_e\left(\frac{q_P^2}{r_e}\right)\alpha_e = 8.19\cdot10^{-14} \tag{2.6}$$

For upcoming sections, it is better to expand Coulomb's constant as the magnetic constant (μ_0) to describe waves, because it is hiding the constant for wave speed (c). The relation of these two is found in Eq. 2.7. Eq. 2.4 is then rewritten to substitute for the magnetic constant and wave speed.

$$k_e = \frac{\mu_0 c^2}{4\pi} \tag{2.7}$$

$$E = \frac{\mu_0 c^2}{4\pi}\left(\frac{A^2}{r}\right) \tag{2.8}$$

The magnetic constant can be further derived, showing the properties of the one-dimensional spring-mass with a mass of Planck mass, a radius of Planck length, and such mass being displaced a distance of Planck charge. The following is the derivation of the magnetic constant in Planck units.

$$\mu_0 = \frac{4\pi m_P l_P}{q_P^2} = 1.26\cdot10^{-6}\left[\frac{kg}{m}\right] \tag{2.9}$$

The units of Eq. 2.9 are of particular importance. A mass times a length, divided by length squared is SI units of kilogram per meter. This is a linear density. Section 4 will explain this density property in more detail.

3. Spring-Mass Energy (1D – Series of Connected Masses)

While the mathematics of harmonic motion of a single mass from the previous section work, it is difficult to imagine that a center mass within a particle vibrates potentially to infinity to affect other particles. It is more likely that it has a cascading effect, with multiple masses in motion, each vibrating and returning to equilibrium. This can be modeled like a spring-mass system with masses connected in series such as the next figure.

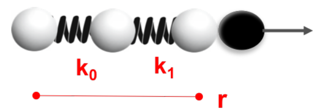


Fig. 8 – Spring-mass system of multiple masses connected in series with spring constants (k_0, k_1, etc).

In a spring series system, the spring constant equivalent (k_{eq}) can be found knowing the spring constant values of each spring in the system [8]:

$$\frac{1}{k_{eq}} = \frac{1}{k_0} + \frac{1}{k_1} + \frac{1}{k_2} + etc \qquad \textbf{(3.1)}$$

It is assumed that there is uniformity such that the spring constant between each mass is constant. Thus, if each unit is a spring constant (k_0), then the equivalent spring constant is based on the number (n) of springs with this constant:

$$\frac{1}{k_{eq}} = n\left(\frac{1}{k_0}\right) \qquad \textbf{(3.2)}$$

The spring constant (k_0) is now determined for the smallest length, which is the radius of the mass (Planck length – l_P). The number of these spring lengths for hydrogen is the Bohr radius divided by Planck length. Then, Eq. 2.3 is used to determine the equivalent k value for the system, based on Coulomb's constant. The values from Eqs. 3.3 and 3.4 are then substituted into Eq. 3.2 to yield the value of k_0.

$$n_h = \frac{r_h}{l_P} \qquad \textbf{(3.3)}$$

$$k_{eq} = \frac{k_e}{r} \qquad \textbf{(3.4)}$$

$$k_0 = n_h\left(\frac{k_e}{r_h}\right) = 5.56081 \cdot 10^{44} \left[\frac{kg}{s^2}\right] \qquad \textbf{(3.5)}$$

Knowing the unit spring constant value (k_0), energy values can be calculated if the number of springs (n) in the system is also known. It can be calculated by dividing measured distance (r) by the Planck length:

$$n = \frac{r}{l_P} \tag{3.6}$$

The equivalent spring constant is now replaced for springs in series:

$$k_{eq} = \frac{k_0}{n} \tag{3.7}$$

The final equation for the energy of a series of connected masses becomes:

$$E = \left(\frac{1}{n}\right) k_0 A^2 \tag{3.8}$$

Eq. 3.8 is used to calculate the energies at the four distances placed in Table 1. The spring constant value for individual springs, k_0, is found in Eq. 3.5, and the number of springs (n) uses Eq. 3.6. All energy values are found to be equal to the calculations from previous methods. Electron-based calculations use the fine structure constant again.

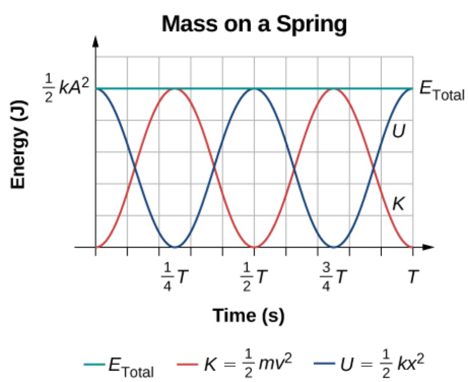
$$E_{lp} = \left(\frac{1}{n_{lp}}\right) k_0 q_P^2 = 1.96 \cdot 10^9 \tag{3.9}$$

$$E_e = \left(\frac{1}{n_e}\right) k_0 q_P^2 \alpha_e = 8.19 \cdot 10^{-14} \tag{3.10}$$

Stored and Kinetic Energy

In the previous sound wave example, three experiments are explained that measure motion, light and weight. Each of these are based on energy, which may change forms, but is always conserved.

In a spring-mass system, a mass on a spring experiences harmonic motion. Its displacement is charted as a sinusoidal wave over time. When a mass reaches maximum displacement, it stops and returns. At this time, there is no kinetic energy but its potential energy is at a max. This is illustrated in the next figure and then mathematically in Eq. 3.11.



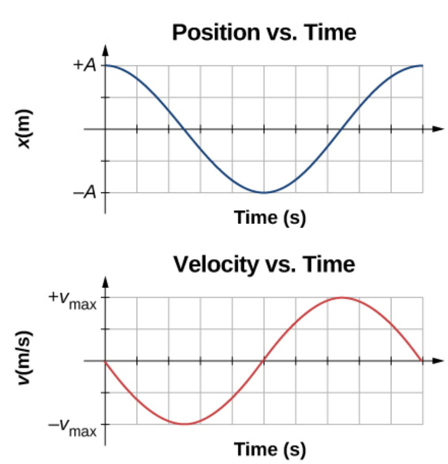


Fig. 9 – Simple harmonic motion and the relation of velocity (v) and displacement (x). [9]

$$E_t = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 \quad \textbf{(3.11)}$$

Similar to previous equations, energy calculations in this paper assume a mass that expands and contracts, returning to equilibrium. Or, it may also be thought of as two waves traveling in opposite directions. This equation becomes:

$$E = mv^2 + kx^2 = kA^2 \quad \textbf{(3.12)}$$

When replacing mass with Planck mass (m_P), velocity with the speed of light (c), the spring constant with the unit spring constant (k_0) and amplitude as Planck charge (q_P), it is found that all are equal to the Planck energy (E_P).

$$E_P = m_P c^2 = k_0 q_P^2 = 1.96 \cdot 10^9 \quad \textbf{(3.13)}$$

This shows the relationship between stored energy and kinetic energy.

Stored Energy

In one of three experiments to measure energy described earlier, energy is contained in a volume and measured by weighing it. Particles, such as the electron and proton, and the atoms that they form are measured as energy or mass. It is stored energy, as particles like the electron may annihilate and release their energy in photons. Earlier, this stored energy was described as standing waves, where there is motion but no net propagation of energy. The average displacement (x) is zero.

From Eq. 3.12, and also illustrated in Fig. 9, when **x=0, v is max**. At this point, it reaches a maximum velocity of the speed of light (c).

$$E = mc^2 \quad \textbf{(3.14)}$$

Kinetic Energy (as a Force)

In another experiment to measure energy, the motion of a nearby object can be calculated as a force, such as the ping pong ball moving away from the speaker due to sound waves. Energy is force over distance. In particles, this force is calculated as the electric force repelling or attracting particles and calculated by Coulomb's law.

From Eq. 3.12, and also illustrated in Fig. 9, when **v=0, x is at its max**. This is the maximum displacement amplitude (A). The next two equations are the energy of the spring-mass system and spring constant from earlier in this section. Eq. 3.17 replaces amplitude with the elementary charge, which has been used for all the electron-based calculations. This is substituted to become Eq. 3.18.

$$E = kA^2 \quad \textbf{(3.15)}$$

$$k = \frac{k_e}{r_h} \tag{3.16}$$

$$A^2 = (q_P^2)\,\alpha_e = e_e^2 \tag{3.17}$$

$$E_h = \frac{k_e}{r_h}(e_e^2) = 4.36 \cdot 10^{-18} \tag{3.18}$$

Eq. 3.18 uses the Bohr radius (r_h), calculating the Coulomb energy at this distance. However, it is more commonly expressed as a force (F), which is energy divided by distance. Eq. 3.19 is the force of two particles at a distance of the Bohr radius. When distance (r) is variable, and charge (q) is the summation of elementary charges, it is more commonly known as Coulomb's Law (Eq. 3.20).

$$F_h = \frac{E_h}{r_h} = k_e\left(\frac{e_e^2}{r_h^2}\right) = 8.24 \cdot 10^{-8} \left[\frac{kg\,(m)}{s^2}\right] \tag{3.19}$$

$$F = k_e\left(\frac{q_1 q_2}{r^2}\right) \tag{3.20}$$

Kinetic Energy (as a Photon)

In a third experiment to measure energy, light is captured. In fact, any electromagnetic wave, not just light, can be captured. Radio waves, light, gamma rays, etc are all transverse waves of different frequencies (f). Eq. 3.12 will be used again as the starting point, but for half the energy. As explained earlier, photon energies are half the energy values at a distance from nucleus. It is given notation E_t for transverse energy. The spring constant is substituted using Eq. 3.16 and amplitude (A) is substituted with the Planck charge and fine structure constant, consistent with all electron-based calculations in this paper. Finally, Coulomb's constant is replaced from Eq. 2.7.

$$E_t = \frac{1}{2}kA^2 \tag{3.21}$$

$$E_{t\,(h)} = \frac{1}{2}\frac{k_e}{r_h}(q_P^2)\,\alpha_e \tag{3.22}$$

$$E_{t\,(h)} = \frac{1}{2}\frac{\mu_0 c^2}{4\pi}\left(\frac{q_P^2}{r_h}\right)\alpha_e = 2.18 \cdot 10^{-18} \tag{3.23}$$

The previous energy value is the Rydberg unit of energy (2.18 x 10^{-18} joules), which is the ionization energy of a photon from hydrogen's ground state (1s). This is also half the value of the energy placed in Table 1 for hydrogen.

Rearranging these terms derives the Planck constant (h), separated in Eq. 3.24 to the left in parentheses. The remaining terms on the right are frequency (f), which is the variable in the Planck relation. This is the energy equation for light and the electromagnetic spectrum (E=hf).

$$E_{t(h)} = \left(\frac{1}{2}\mu_0 c q_P^2\right)\left(\frac{\alpha c}{4\pi r_h}\right) \tag{3.24}$$

$$h = \frac{1}{2}\mu_0 c q_P^2 = 6.63 \cdot 10^{-34} \left[\frac{kg\,(m^2)}{s}\right] \tag{3.25}$$

$$E = hf \tag{3.26}$$

The equations that model the behavior of three experiments for motion, light and weight can be derived from a spring-mass system. Nevertheless, there are still issues. There is only one variable in Eq. 3.24. If it was only distance that determined the photon's energy, it would have been easier to predict and model quantum behaviors.

4. Wave Energy (1D)

When two or more waves collide and combine, constructive wave interference occurs changing the resultant amplitude of the collective wave. It is this property of waves that is missing in the equation for frequency in Eq. 3.24. It is also important for the creation of particles, which will be explained in Section 5.

Wavelength is another variable property of waves. Transverse wavelengths and frequencies may vary based on the speed at which a particle vibrates. And longitudinal wavelengths may vary when a particle is in motion, experiencing the Doppler effect and responsible for relativistic behaviors. It is for this reason that wave equations are preferred.

A simple equation for the energy of a wave in a volume (V) with a given density (ρ), wave speed (c) and amplitude (A) that declines with distance (r) is shown in Eq. 4.1:

$$E = \boldsymbol{\rho} V c^2 \left(\frac{A}{r}\right)^2 \tag{4.1}$$

Earlier in Eq. 2.9, the magnetic constant was derived and shown to be a linear density, with units of kg/m. This represents the density between two particles, as it is a property that was determined from measuring the forces of these particles. Fig. 10 illustrates two particles separated a distance r, and the volume between them as a pyramid with height (r) and base width and length (r_e). The pyramid shape is often used to describe forces and how such force decreases with distance. In this case, it acts upon the electron at distance and the base of the pyramid is the electron's radius. *Note the pyramid base should be 2 times radius, but it corrects for the Planck charge which is 2 times amplitude and they both cancel in the upcoming Eq. 4.5.*

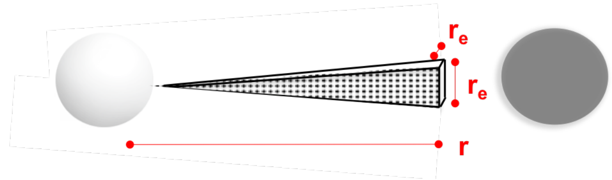


Fig. 10 – Linear density derived from a volume (V) of pyramid shape with length r and base/width r_e.

The density calculated from Eq. 3, using the Planck mass and the volume of hydrogen is shown again in Eq. 4.2. Now, the linear density from the magnetic constant is converted to density by dividing the volume of the electron, since this constant is based on electron calculations. *Note that it is divided by the square of the electron radius, not cube, since the magnetic constant is already a linear density with one electron radius accounted for in the constant.*

$$\rho = \frac{m_P}{\frac{4}{3}\pi r_h^3} = 4 \cdot 10^{22} \left[\frac{kg}{m^3}\right] \tag{4.2}$$

$$\rho = \frac{\mu_0}{\frac{4}{3}\pi r_e^2} = 4 \cdot 10^{22} \left[\frac{kg}{m^3}\right] \tag{4.3}$$

Both density values, when rounded, are 4 x 10^{22} (kg/m^3). This is also the same density derived a third way in energy wave equations, although a more refined value of 3.86 x 10^{22} is used for density when considering g-factors [10].

Given that the magnetic constant is a linear density, a special volume is used as described in Fig. 10. The volume of the pyramid is:

$$V = \frac{1}{3} r_e^2 (r) \tag{4.4}$$

Next, the 1D wave equation from Eq. 4.1 is used, then substituted for density (Eq. 4.3) and volume (Eq. 4.4). After simplifying, it becomes the single mass spring equation (Eq. 2.4), showing that the equations are identical.

$$E = \rho V c^2 \left(\frac{A}{r}\right)^2 = \frac{\mu_0}{\frac{4}{3}\pi r_e^2}\left(\frac{1}{3} r_e^2 r\right) c^2 \left(\frac{A}{r}\right)^2 = \frac{\mu_0}{4\pi} c^2 \left(\frac{A^2}{r}\right) = k_e c^2 \left(\frac{A^2}{r}\right) \tag{4.5}$$

As the equations are equal, the values are also the same and placed into Table 1.

5. Wave Energy (3D)

While the wave and spring-mass equations work for forces and photons in one-dimension, it doesn't adequately describe particles. It works for forces between two particles because a one-dimensional line can be drawn between particles. However, particles are three-dimensional objects.

Fig. 11 describes a spherical particle, generating energy flowing as waves with a defined wavelength and an amplitude that decreases from the center. It includes a transition between standing waves and traveling waves, for a definition of a particle's stored energy boundary. Energy continues beyond this boundary as kinetic energy that may cause motion of nearby particles or create photons from their transverse vibration.

These longitudinal waves have an amplitude (A) that may change based on constructive wave interference with other particles, and particle motion is an effect of moving the wave center to equalize amplitude. The longitudinal wave has a constant wavelength, but it may change based on motion, consistent with the Doppler effect [11].

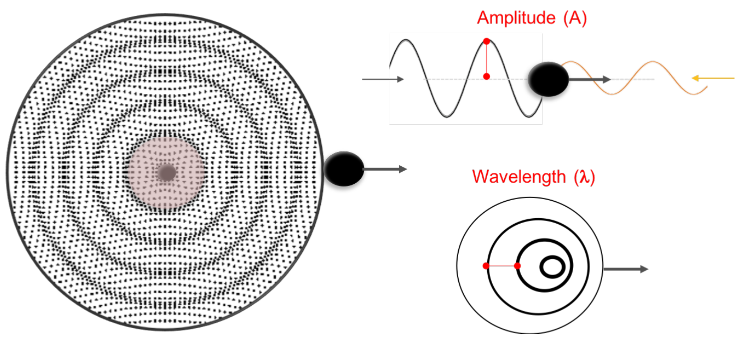


Fig. 11 – Wave energy in a spherical volume with variable amplitude (A) and a wavelength (λ) that changes with motion.

The 1D version of wave energy from the previous section is shown again and compared to the 3D version in Eq. 5.2:

$$E_{1D} = \rho V c^2 \left(\frac{A}{r}\right)^2 \quad \textbf{(5.1)}$$

$$E_{3D} = \rho V c^2 \left(\frac{A^3}{r^3}\right)^2 = \rho V \left(\frac{c}{\lambda}\right)^2 \left(\frac{A^3}{r^2}\right)^2 \quad \textbf{(5.2)}$$

The three-dimensional creation of the equation includes wave amplitude (A) in three dimensions (A^3). It decreases with distance, but now wavelength is considered. One of the squares in which wavelength is included becomes the in-wave frequency ($f=c/\lambda$) and the other component of the square is the out-wave frequency. Each in-wave and out-wave has a three-dimensional amplitude decreasing at the square of distance. The volume is now spherical.

$$V = \frac{4}{3}\pi r^3 \quad \textbf{(5.3)}$$

One of the benefits of using the Wave Energy (3D) equations is calculating particle energies beyond the electron. Energies from the neutrino to the Higgs boson were calculated using a method that considers constructive wave interference for multiple *wave centers* (K) combined at a core, much like how protons (and neutrons) combine at the core of an atomic nucleus. Due to similarities with atomic elements, the findings were linearized and then organized into a periodic structure and reported in a separate paper [12].

Without reproducing all the steps in that paper, the derivation of Eq. 5.2 into an equation that calculates the energy of standing, longitudinal waves is found in Eq. 5.4. All constants are placed in the Appendix. The only variable in the equation is the count of wave centers (K) at the core of the particle. The energy of a single wave center (E_ν) is calculated in Eq. 5.5. The energy of the electron (E_e) is found with a count of 10 wave centers.

$$E_{l(K)} = \frac{4\pi\rho K^5 A_l^6 c^2}{3\lambda_l^3} \sum_{n=1}^{K} \frac{n^3 - (n-1)^3}{n^4} \tag{5.4}$$

$$E_v = \frac{4\pi\rho (1)^5 A_l^6 c^2}{3\lambda_l^3} \sum_{n=1}^{1} \frac{n^3 - (n-1)^3}{n^4} = 3.83 \cdot 10^{-19} \tag{5.5}$$

$$E_e = \frac{4\pi\rho (10)^5 A_l^6 c^2}{3\lambda_l^3} \sum_{n=1}^{10} \frac{n^3 - (n-1)^3}{n^4} = 8.19 \cdot 10^{-14} \tag{5.6}$$

In Section 4, it was found that 1D wave and 1D spring-mass equations were equal. This is not surprising since a speaker creates sound waves. So, it follows that 3D waves and 3D spring-mass systems should also be equal. To model electron-based behaviors using a 3D spring-mass system, a spring constant (k_3) was determined. *Note this k has different units than a 1D spring constant k.*

$$k_3 = 1.36395 \cdot 10^{85} \quad \left[\frac{kg}{m^3 s^2}\right] \tag{5.7}$$

Because it is used to calculate energies based on the electron, the elementary charge is used. This equation is the only method that does not work to calculate the Planck energy in Table 1. The equation for this method is:

$$E = k_3 \left(\frac{e_e^6}{r}\right) \tag{5.8}$$

$$E_e = k_3 \left(\frac{e_e^6}{r_e}\right) = 8.19 \cdot 10^{-14} \tag{5.9}$$

Eq 5.8 is used to calculate the electron's rest energy in Eq. 5.9. The same steps were taken using the equation to solve for the energies of hydrogen and helium and all results were placed into Table 1. All values for all methods used in this paper are equal.

Conclusion

As implausible as it could be that sound exists without air, it is equally strange to consider that electromagnetic waves are explained as waves traveling through space in which no medium exists. Empty space. Nevertheless, the mathematics were shown to be the same when modeling empty space as radiating energy, as a massive particle vibrating in a spring-mass system, or as multiple particles vibrating as a spring-mass or calculated as the formation of waves. Sound waves were used as a physical model to explain this behavior but the values for air molecule size and mass were replaced with subatomic scales. The equations are equal regardless of values. Thus, shouldn't it be possible that the universe could be filled with Planck-sized objects that vibrate in harmonic motion to create waves?

At the very least, it has been shown that subatomic particles and the atoms which they form can be modeled with classical mechanics, by using 5 different methods in this paper. This finding is significant because of the simplification of all objects in the universe, from the smallest of particles to the largest of galaxies, obeying the same laws of physics. It leads to the possibility of computer simulations that can model the behavior of particles and atoms. While this paper calculates energies of atoms for the first two elements – hydrogen and helium – the framework has also been set for the calculations of atoms beyond helium in a separate paper. Furthermore, the framework has been set for the calculations of particle energies beyond the electron.

It is the conclusion of this paper that wave equations that model three-dimensional spherical particles best represents the true nature of the subatomic realm, not only for their ability to calculate the energies of electron-based experiments found in Table 1, but also because natural properties of waves explain relativistic effects and quantum behaviors. Variable wavelengths allow for classical mechanics equations to explain relativity as a change in wavelength for a particle in motion and constructive wave interference that affects wave amplitude accounts for quantum behaviors.

Appendix

Constants

The following constants are used in this paper, separated by the distances used in energy calculations, classical constants (CODATA values), wave constants found in Energy Wave Theory (EWT) and other constants calculated in this paper.

Symbol	Definition	Value (units)
	Distances	
l_P	Planck length	1.6162×10^{-35} (m)
r_e	Electron classical radius	2.8179×10^{-15} (m)
r_h	Hydrogen 1s radius (Bohr radius – a_0)	5.2918×10^{-11} (m)
r_{he}	Helium 1s radius	3.0×10^{-11} (m)[a]
	Classical Constants	
c	Wave velocity (speed of light)	299,792,458 (m/s)
m_P	Planck mass	2.1765×10^{-8} (kg)
E_P	Planck energy	1.9561×10^{9} ($kg*m^2/s^2$)
k_e	Coulomb constant	8.9876×10^{9} ($kg*m/s^2$)[b]
μ_0	Magnetic constant	1.2566×10^{-6} (kg/m)[b]
q_P	Planck charge	1.8756×10^{-18} (m)[b]
e_e	Elementary charge	1.6022×10^{-19} (m)[b]
α_e	Fine structure constant	0.00729735
e	Euler's number	2.71828
	Wave Constants	
A_l	Amplitude (longitudinal)	$9.215405708 \times 10^{-19}$ (m)
λ_l	Wavelength (longitudinal)	$2.854096501 \times 10^{-17}$ (m)
ρ	Density (aether)	$3.859764540 \times 10^{22}$ (kg/m^3)
	Other Constants	
m_g	Granule mass	1.18936×10^{-80} (kg)
N	Number granules in hydrogen	1.82995×10^{72}
k_0	Unit spring constant (1D)	5.56081×10^{44} (kg/s^2)
k_3	Unit spring constant (3D)	1.36395×10^{85} (kg/m^3*s^2)

[a] – Helium 1s radius uses 30pm instead of an estimated 31pm to fit experimental data [13].
[b] – Corrected units when units of Coulombs (C) is replaced with distance (meters).

Table 2 – Values and units of constants used in this paper

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