Simulating Standalone Particles

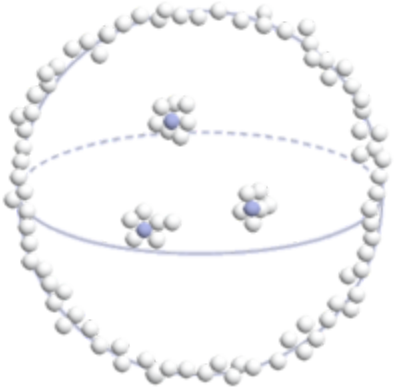
Phase 2 Requirements

Simulating Standalone Particles

Initial Conditions | Runtime | Validation

Objective

To simulate the creation of simple, standalone particles that may form and decay, with stability at certain geometries. The electron and its antiparticle, the positron, should form during this phase.



Validation Criteria

The following should be validated in this phase of the project:

1. Formation of particles matching energy values expected with neutrino combinations.
2. Formation of the electron particle.
3. Formation of the positron particle.

4. Detection of magnetic transverse, spin waves.

Custom Simulator vs Blender Add-On

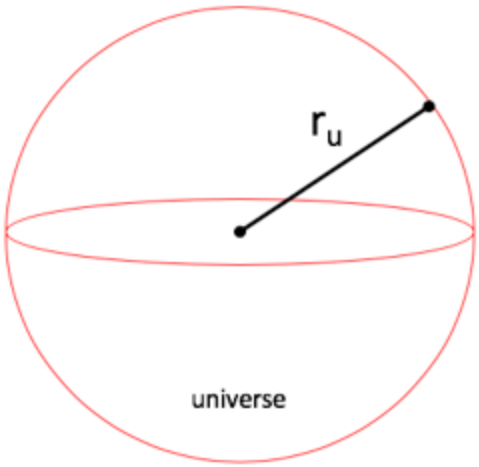
These requirements are intended for developers building a custom simulation. The Quantum Microscope for Blender Add-On was developed using these requirements but were adjusted for scale and Blender's capabilities. The modifications for Blender are found at the end of each section (Initial Conditions, Runtime and Validation). A list of suggested improvements for the Add-On are found in the source code and their ReadMe files.

Initial Conditions

The initial conditions from phase one should be used for this phase with the exception of the following changes and additions.

2.1 Universe Size

For phase two and beyond, the size of the simulated universe will need to support particle formation, and eventually molecule formation. A new option to configure the size of the simulated universe (*spacetime*) can be added for greater control.



A larger simulated universe size increases the number of granules in the simulation, so the following should be considered:

- A scaling factor may be applied to reduce the number of granules in the simulated universe, for both human eye visualization and some calculations (e.g. forces between particles at large distances).
- When performing calculations requiring more detail (e.g. energies of particles), a specific volume within the simulation may be selected at runtime such that initial conditions are used without the scaling factor to accurately calculate granule energy within such defined volume.

Why? *The radius of the universe needs to be large enough to create an electron (10^{-15}) in this phase and will eventually need to support the formation of molecules in later phases. However, increasing the number of granules also increases the number of calculations in the simulation. Methods, to be determined by the developer, can be used to localize these calculations to support a larger simulated universe.*

2.2 Number of Wave Centers

The number of wave centers (neutrinos) should be increased from phase one. The simulation can be run many times, first starting with low numbers of wave centers (e.g. up to ten), and then with larger numbers (e.g. up to 120).

2.3 Initial Wave Amplitude

New configuration options can be added to simulate higher energy levels, seen in particle accelerators creating new particles, or potentially higher energies seen in the early universe.

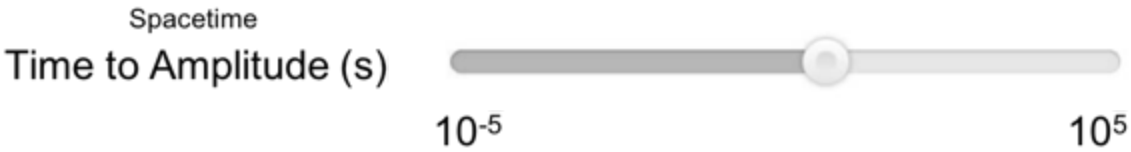
The *Spacetime Initial Amplitude* is a different wave amplitude than the default *Spacetime Amplitude* carried over from Phase 1. The former can be thought of like the initial amplitude/energy of the universe and the latter like today's amplitude/energy of the universe. The initial amplitude may be set to be higher than the default amplitude and decreases to the default over a preset time.

Initial Wave Amplitude

The longitudinal wave amplitude (A_l) from phase one is now set to the initial wave amplitude at the start of runtime. It may initially be set to the same default property from phase one, but can be adjusted (likely higher) by the user.

Time to Amplitude

The longitudinal wave amplitude (A_l) decreases, or increases, from the *Spacetime Initial Amplitude* to the *Spacetime Amplitude* over the time defined by the *Time to Amplitude* property (in seconds). Once it reaches this time, it remains constant at the defined *Spacetime Amplitude* until the end of runtime. For example, the spacetime initial amplitude may be set to 1 x 10^{-15} meters for 100 seconds. The value of A_l is set to this value and then declines linearly for 100 seconds, eventually reaching the spacetime amplitude value (e.g. 9 x 10^{-19} m), then remaining at this amplitude value.



Why these options? *Some particles only form during high energy events, such as particle accelerators like CERN. This option allows energy to be injected into the system, controlling how much energy and for how long, until reaching default values that match data from stable particles measured on Earth today.*

Blender Add-On Modifications

The Quantum Microscope Add-On for Blender uses these requirements with the following modifications:

1. Instead of an option to scale the universe, the various phases are set as different modules in the Blender Add-On with different scaling properties for each phase. At this phase, the neutrino's diameter is set to 1 meter as the baseline for scaling.
2. The number of wave centers is configurable, but is titled number of *neutrinos*.
3. Instead of a configurable wave amplitude, a configurable external force is provided instead (force and energy are proportional to amplitude).
4. The external force has a default time to be turned off, which is based in Blender keyframes, not seconds. It is set in the config.py file and its default is 20 keyframes.

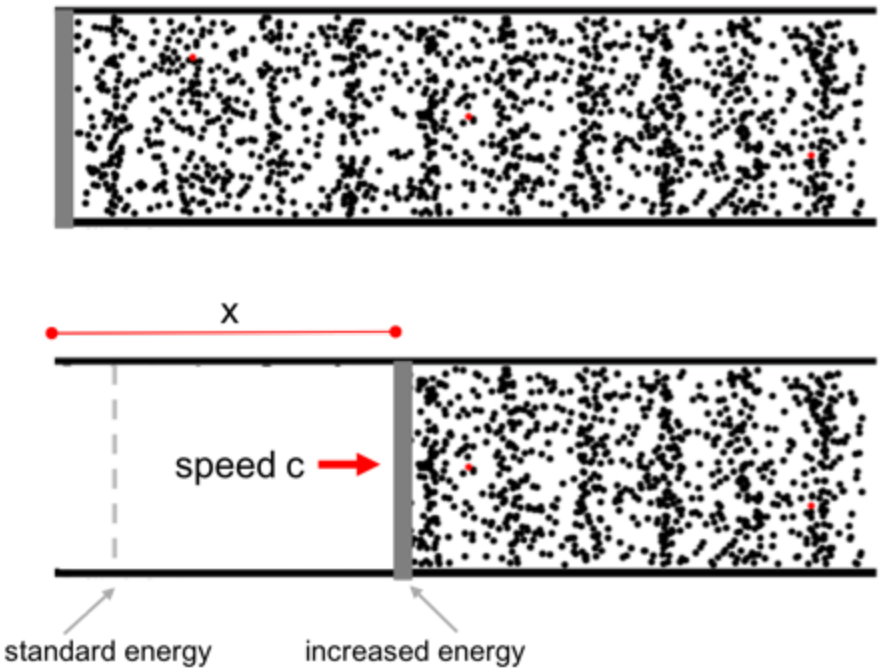
Runtime

Some of the known particles, especially lepton particles created naturally, are likely a combination of wave centers and can be produced in this phase at runtime. The most notable lepton is the electron.

2.4 Inject Additional Energy

Additional energy should be injected into the universe to form higher-order particles that are not possible to create under current energy levels of the simulated universe in phase one.

The next figure illustrates the displacement distance from the edge of the universe. The "standard energy" is the default amplitude property (*Spacetime Wave Amplitude),* and "increased energy" is the initial amplitude (*Spacetime Initial Amplitude*). At the start of runtime, the amplitude displacement is the latter initial amplitude, decreasing (or increasing) to be the default amplitude over the time property (*Time to Amplitude)*. The wave speed should remain constant, at the speed of light (c).



Increasing energy into the universe

Why? *The early universe may have had different properties that allowed the formation of particles like the electron, or later the proton (next phase). Even today, particle accelerators such as CERN have the ability to produce new particles at high energy levels.*

2.5 Physics of Motion

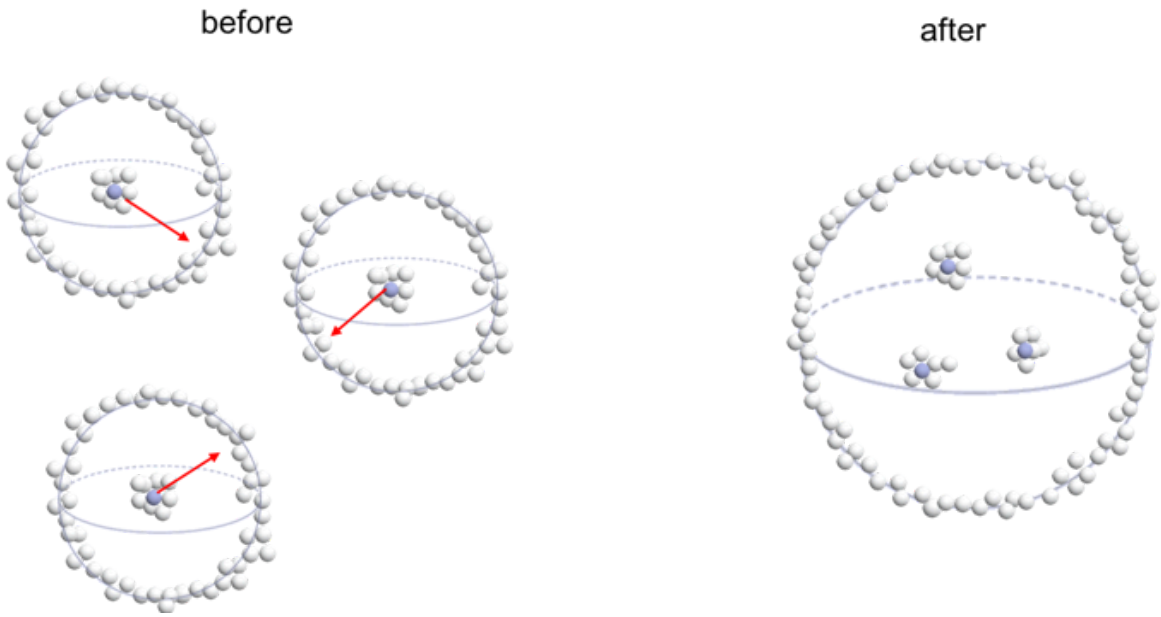
The physics of granule motion from phase one should remain unchanged. However, there should be new wave forms to detect as it is possible that transverse waves may appear in this phase.

Wave Center Combination (K)

At the start of runtime, each wave center is randomly placed into the simulation and tracked for motion. From the physics established in phase one, wave center motion should be in the direction of minimal wave amplitude (energy). This should allow wave centers to move throughout the lattice. There will be the possibility that wave centers, when in proximity of other wave centers, will combine to form new particles. Note if wave centers are not freely moving through the lattice, the *Wave Center Separation Force* property may be adjusted.

During runtime, each wave center should be tracked for its position, and when in proximity of another wave center (e.g. within one wavelength), the surrounding volume should be checked for a change in standing wave formation. When a new formation occurs, the total wave center count within the standing wave formation should be recorded. It is assigned the letter **K**.

For example, in the illustration below, each fundamental particle (neutrino) is assigned a value K=1 for one wave center within its standing wave formation, as shown in the figure **before** the merger of these three individual neutrinos. **After** the merger of the neutrinos in the next figure, a new standing wave formation is identified where three wave centers existing within the boundary. In this example, the newly formed particle should be assigned a value K=3, for three wave centers.



Wave Center Count (K): before each particle is K=1, after combination of three, K=3

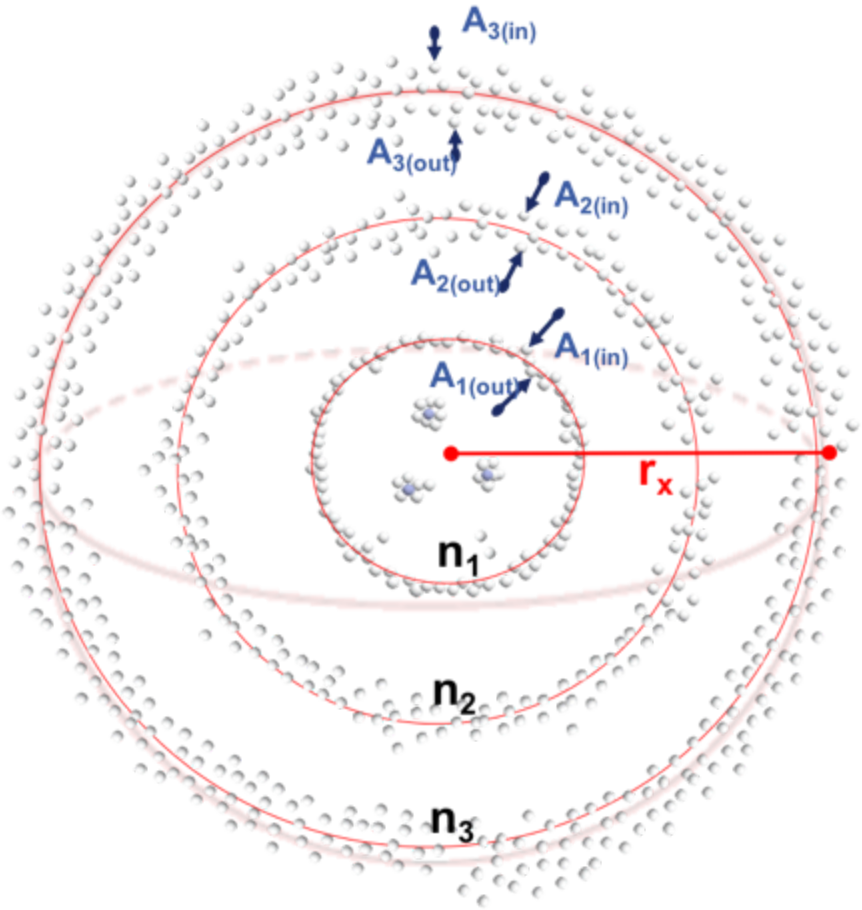
It is expected that wave centers will only be stable at standing wave nodes, leading to very few geometries that are stable. A particle formation time (t_x) from the first detection of a new standing wave formation to the formation ceasing to exist can be monitored as particle decay time.

Standing Wave Formation (r and n)

As new particles form from a collection of wave centers, a greater amplitude should be seen at the core of the new particle. This should lead to an increase in the particle's radius, measured from the center of standing wave formation to the boundary of standing waves. This radius should be recorded for each particle formation as $\mathbf{r_x}$.

It is likely that there may be multiple standing wavelengths for particles that are a combination of wave centers. For example, in the next figure, three wave centers combine to form a new particle with a formation of standing waves with three wavelengths. The total number of wavelengths should be recorded as **n**.

Each wavelength has an assigned longitudinal amplitude value, and it is expected that amplitude decreases with each wavelength (e.g. A_1, A_2, A_3).



Standing wave radius

Blender Add-On Modifications

The Quantum Microscope Add-On for Blender allows this runtime execution with the following modifications:

1. Energy may be injected by adjusting the External Force (force and energy are related by distance).
2. Standing waves and their node positions are created manually (as opposed to wave reflections automatically creating standing waves).
3. Particle spin has a 1/2 spin (two rotations to return to normal position), but it uses Blender keyframe animation to accomplish it.

The issue with the creation of standing waves and particle spin are documented in the ReadMe file.

Validation

The following should be validated during the simulation.

2.6 Formation of Standalone Particles

During runtime, multiple particle formations may occur as random events as wave centers collide. Some will be relatively stable and others may occur quickly and decay to particles with a smaller number of wave centers. When a formation of two or more wave centers create a new standing wave formation, it should be visually recognized in the computer simulation. The particle's radius is the boundary of standing waves from its core. The particle's energy can be calculated and validated against known particles.

Validation

For each wave center in the simulation, the number of wave centers within its standing wave formation (K) and its standing wave radius (r_x) is calculated and shown as the output. The following wave constants can be used to calculate energy:

- ϱ – density from initial conditions
- c – speed of light from initial conditions
- A_l – longitudinal amplitude from initial conditions
- λ_l – longitudinal wavelength from initial conditions
- K – number of wave centers within standing wave formation from runtime
- n – number of wavelengths in standing wave formation from runtime
- E_v – the neutrino energy value calculated in phase one.

The energy equation is the same as phase one, which is based on frequency and amplitude squared, in a given volume of known density. But now, it is given sub-notation x for particles with differing volumes and amplitudes.

$$E_x = \rho V_x (f_x A_x)^2$$

Where volume is spherical, but considers the summation of energy calculating spherical shells of declining amplitude. For more information on this equation, refer to the *Geometry of Particles* paper. The number of wavelengths of standing waves (n) should be equal to the wave center count (K), or this volume equation will be inaccurate.

$$V_x = \frac{4}{3}\pi (K\lambda_l)^3 \sum_{n=1}^{K} \frac{n^3 - (n-1)^3}{n^4}$$

Frequency remains the same:

$$f_x = \frac{c}{\lambda_l}$$

Amplitude is similar to phase one, but increases in amplitude and wavelength at the core, proportional to the number of wave centers (K):

$$A_x = \frac{(KA_l)^3}{(K\lambda_l)^2}$$

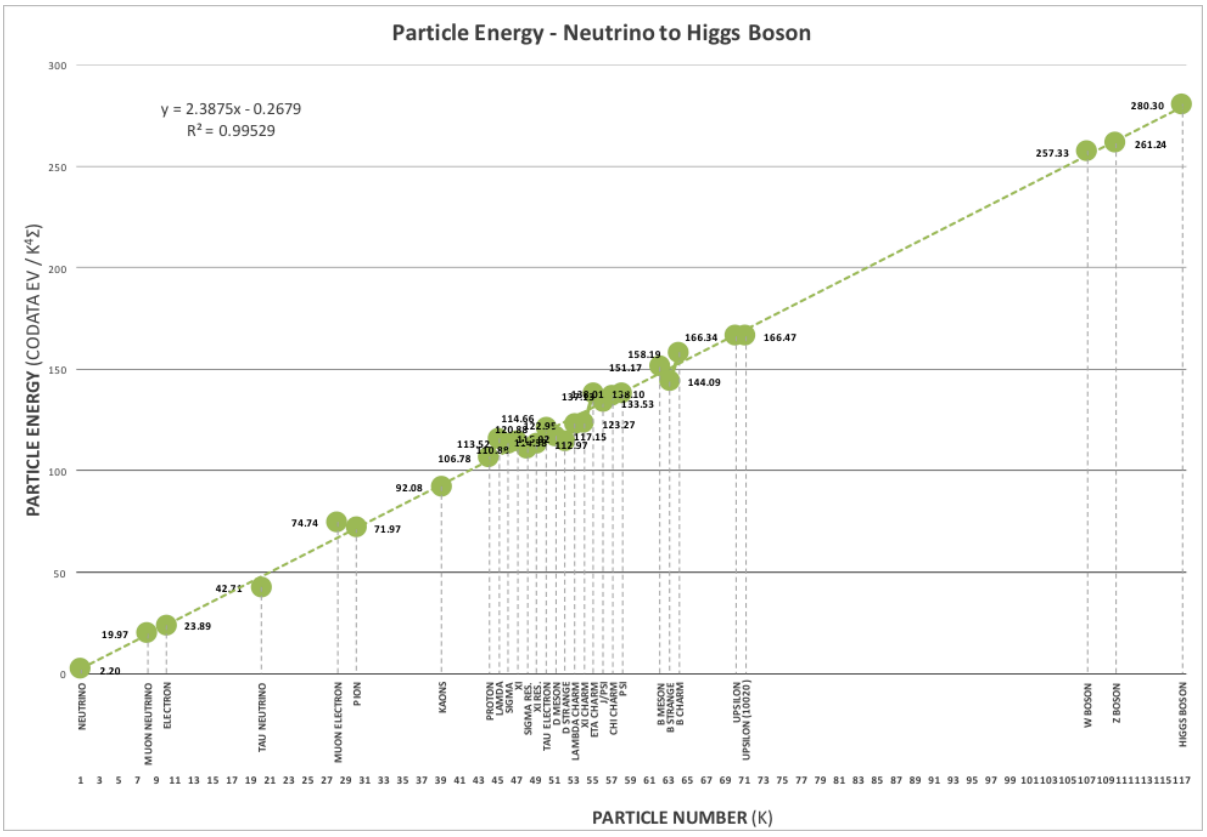
Alternative Method

From the *Geometry of Particles* paper, it was found that the energy equation described above can be simplified to one constant and one variable. The only variable is the number of wave

centers (K). The constants resolve to be the energy of the neutrino particle (E_v). This single constant can be used, along with the following equation, to calculate the energy of particles within standing waves based on the number of wave centers at the core.

$$E_x = E_v K^5 \sum_{n=1}^{K} \frac{n^3 - (n-1)^3}{n^4}$$

Validate: E_x values for each particle formation of wave centers (K). This can be put in tabular format. Assuming the neutrino energy value calculated at phase one is near $E_v = 2.39$ eV, the K values for particles should match the chart below. For example, a particle with 28 wave centers (K=28) should be near 100 MeV matching the muon electron. Or, a particle with 50 wave centers (K=50) should be near 1.8 GeV, matching the tau electron.

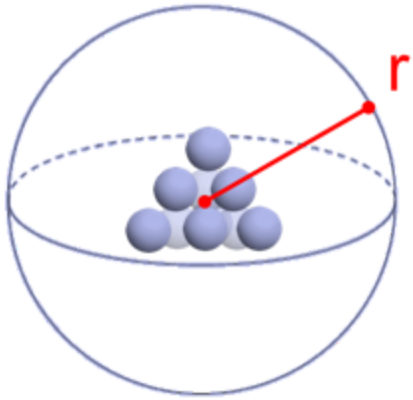


Particles and Energies vs Wave Center Count (K)

About this graph. *Because energy is proportional to wave center count to the fifth power, the energy is divided by the fourth power to linearize in the graph above. This linearization function is much like how atomic numbers (Z) were linearized based on the mass of atomic elements. There is a key difference. Masses of elements can be added together. Masses of particles cannot be added. They must be taken to the fifth power before linearization can be recognized. More information on the graph is available here.*

2.7 Formation of Electron

The electron should form as a combination of wave centers. While many particles quickly decay, the electron should have a geometric formation of wave centers that allows it to be stable, with the exception of annihilation with a positron. It is expected that the stable electron may consist of ten wave centers for reasons explained here. If so, it should look like the following:



Electron

Validation

Particles from Section 2.6 should be scanned during runtime for particles that match the electron's properties. The classical radius of the electron (r_e) can be calculated in the simulation as the distance from the core to the boundary of standing waves (r_x). The electron's energy (E_e) can be calculated using the particle energy equation (E_x) from the previous section 2.6.

Validate: $r_e \approx 2.8 \times 10^{-15}$ meters

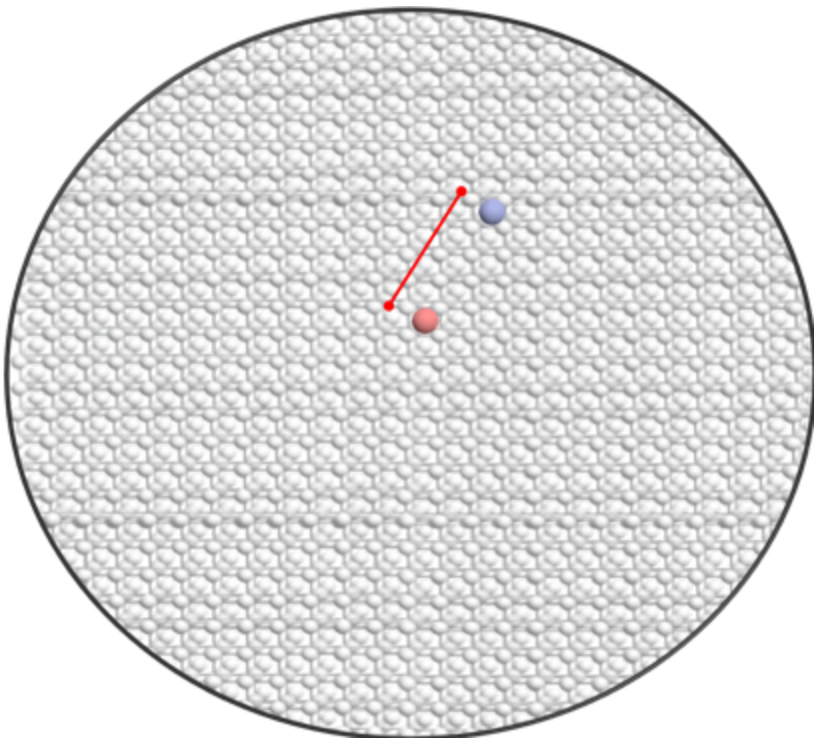
Validate: $E_e \approx 8.2 \times 10^{-14}$ joules (kg m^2/s^2)

2.8 Formation of Positron

While particles matching the electron's properties are being scanned (Section 2.7), there is a probability that the positron will be found. It will be identical to the electron in size and energy, but will be placed on the opposite node of a standing wavelength. A positron can be determined by checking for destructive wave interference between it and an electron, or it may also be attracted and have motion towards an electron. If motion is detected towards an electron, it should eventually combine with the electron, forming a particle with twice as many wave centers, but completely destructive waves such that no standing waves form.

Validation

Select two particles matching the electron's properties in the simulation and graph the displacement (amplitude) of granules in the vector between the two particles (Graph #1).

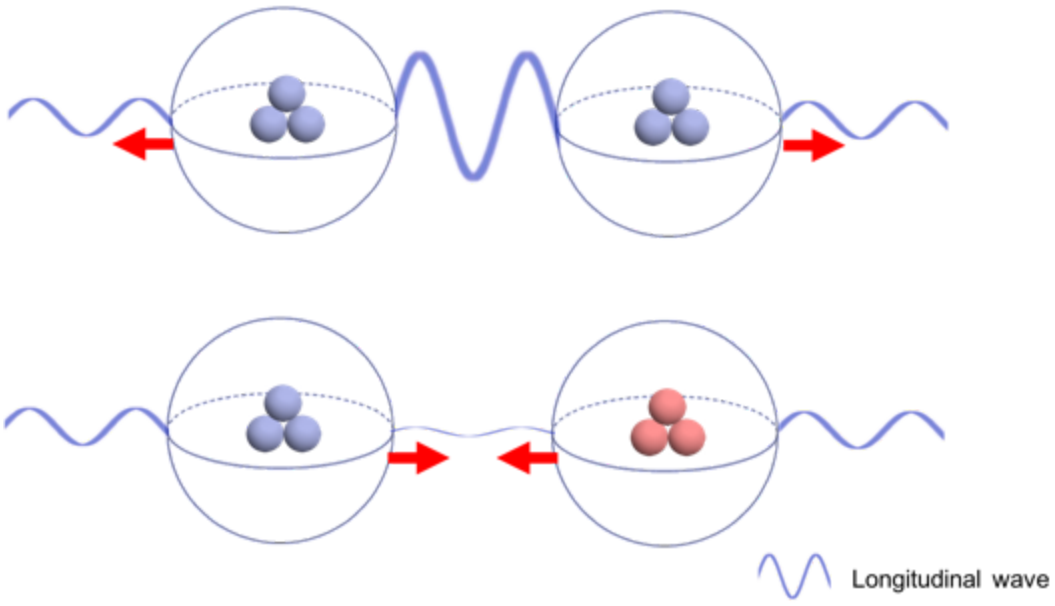


The waves between these two particles should either be constructive, in which case two electrons or two positrons have been chosen. Or they should be destructive, in which case an electron and positron have been chosen. When the latter is detected, it is the validation of the positron.

2.9 Formation of Electric and Magnetic Waves

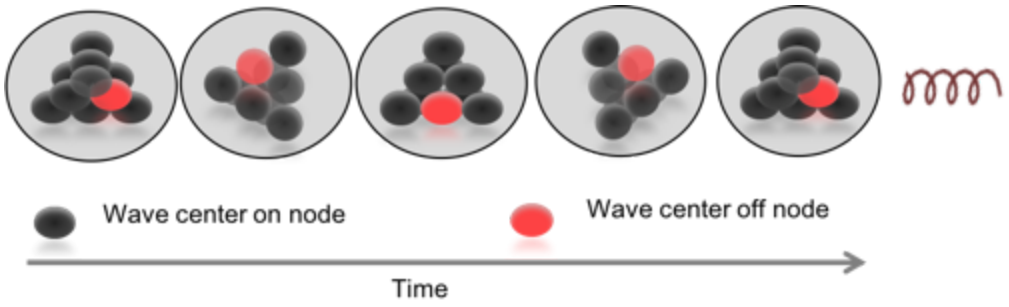
Electric waves are traveling, longitudinal waves. The formation of these waves was validated in phase one. However, now with the formation of the electron particle in this phase, the electric force can be validated as Coulomb's law.

Longitudinal constructive wave interference should force two particles apart, moving in the direction of minimal wave amplitude . Longitudinal destructive wave interference should do the opposite, attracting particles.

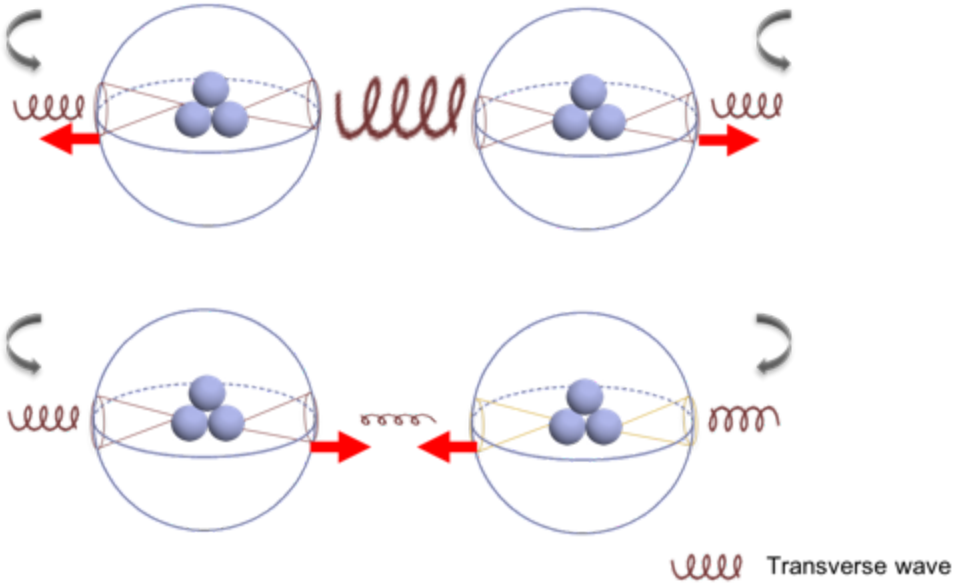


Electric force

The same rule for wave center motion – moving in the direction of minimal amplitude – is the cause of particle decay. And it is also the cause of spin, in a stable particle like the electron. Even a relatively stable formation of wave centers will not be able to contain every wave center on the node of a standing wave. There should be motion of some wave centers to nodes, causing the spin of an electron.



This motion should cause a new wave form, introduced from spin – the magnetic force. In between two particles, it should appear as a transverse wave. Similar to longitudinal wave interference, transverse wave interference can be constructive and destructive. Two particles of same spin will be constructive and repel, two particles of opposite spin will be destructive and be attractive (*when not considering the effect of longitudinal waves*).



Magnetic force

Validation

The electric force **(F_e)** can be validated between two electrons. From the step in the previous section, when two electron particles are identified, the distance (r) between the particles is determined in the simulation. The force should be Coulomb's law for two electrons. Coulomb's law equation should be validated as the force. *Note, the magnetic constant is*

used instead of Coulombs' constant, and the Planck charge squared with the fine structure constant is used instead of the elementary charge (it is identical to Coulomb's law expressed in a different way to show the similarity to magnetism).

- μ_0 – the magnetic constant.
- q_P – the Planck charge.
- α_e – the fine structure constant.

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

The magnetic force **($\mathbf{F_m}$)** may be validated visually in the simulation by the presence of transverse waves originating from a particle like the electron. It may require a zoom in the simulation to see this wave formation given its very small size. The magnetic, transverse wave originating from one pole of an electron is known as a monopole. Monopoles are not found in nature at the macro-level, but in a simulation of a single electron, it may be found. From the *Geometry of Spacetime* paper, the magnetic force of a monopole is expected to be:

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

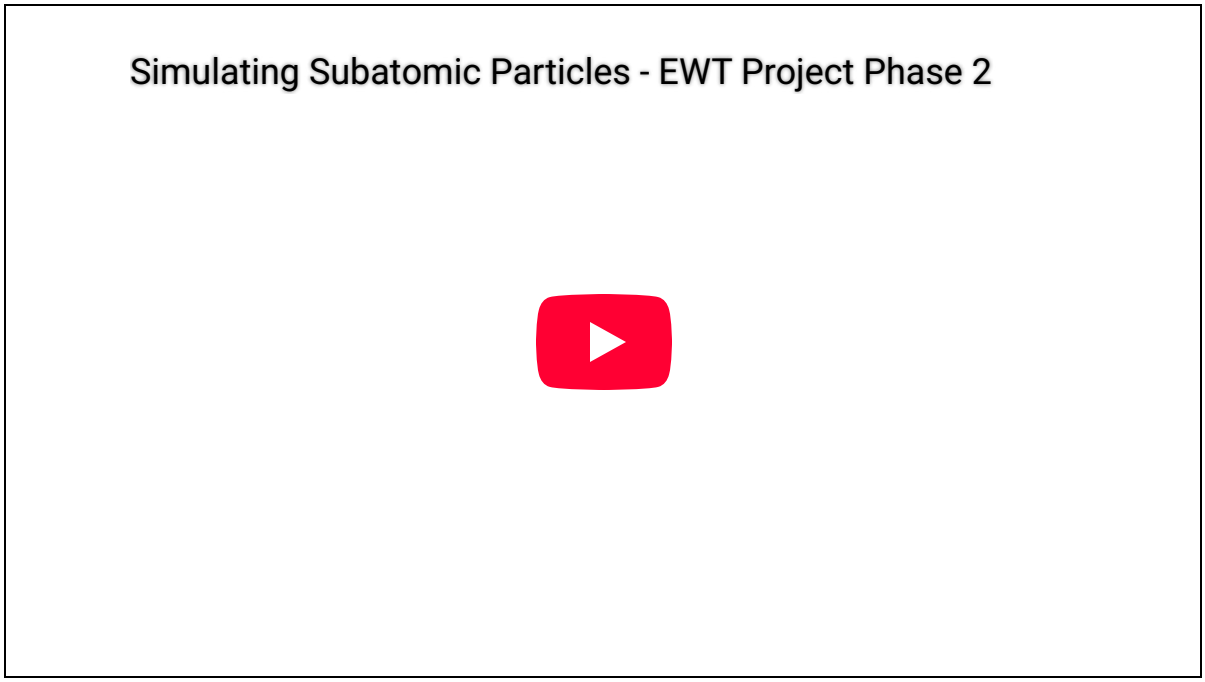
Blender Add-On Validation

The Quantum Microscope Add-On for Blender has issues with validating:

1. Particle energy using the wave validation method. Instead, the Blender Add-On uses the alternative method proposed in the validation steps which was used for the calculation of particles energies, based on the neutrino's energy from Phase 1.
2. Particle stability. Wave center counts from 1 to 14 are stable, which includes the electron, in the Blender Add-On. Higher counts are not stable. Some of the wave center counts that are stable should not be, which is likely an issue inherited by the way standing waves are manually created.

3. The positron and forces between particles. Due to an issue from Phase 1 regarding granules affecting the motion of objects, and the calculation of constructive wave interference, the forces of particles and antimatter could not be validated.

Video Summary



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Next: Simulating Composite Particles