Simulating Composite Particles

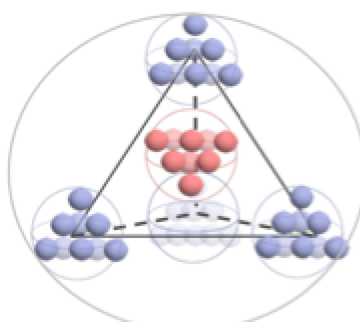
Phase 3 Requirements

Simulating Composite Particles

Initial Conditions | Runtime | Validation

Objective

To simulate the creation of composite particles, including nucleons, made of known standalone particles such as the electron and positron. The proton should form during this phase.



Validation Criteria

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

1. Formation of composite particles including mesons, baryons, tetraquarks and pentaquarks.
2. Formation of the proton particle.
3. Formation of the neutron particle.
4. Detection of the strong force between standalone particles.
5. Detection of a magnetic force responsible for orbitals.

Custom Simulator vs Blender Add-On

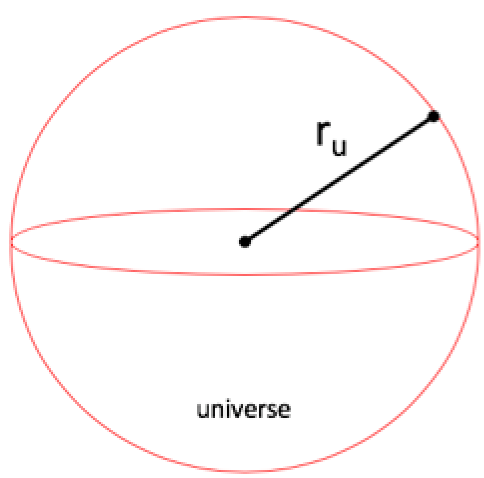
These requirements are intended for developers building a custom simulation. The Quantum Microscope for Blender Add-On was developed using these requirements but were adjusted for scale and Blender's capabilities. The modifications for Blender are found at the end of each section (Initial Conditions, 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 two should be used for this phase with the exception of the following changes and additions.

3.1 Universe Size

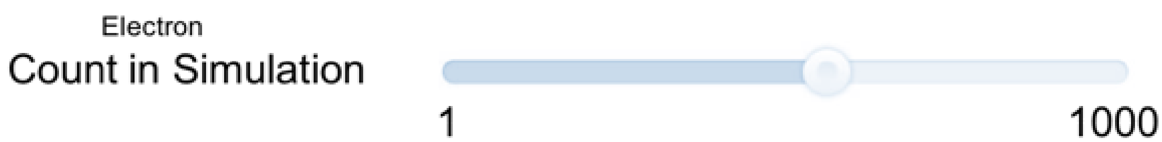
For phase three, the size of the simulated universe will need to support composite particle formation. The radius (r_u) should be set to at least 10^{-13} meters to allow enough standalone particles to roam the universe and potentially collide with other standalone particles.



Why? *Although the radius of the proton, a composite particle, is less than 10^{-15}m, it is formed from other particles. There should be sufficient room for these particles and their collisions to create composite particles.*

3.2 Number of Electrons

The simulation may be run from scratch by randomly placing wave centers into the simulation, replicating the step to form standalone particles from phase two. In this scenario where it is run from scratch, it will take longer for wave centers to form and create standalone particles, and then for standalone particles to create composite particles. An alternative method to save time is to randomly inject electrons into the simulation, along with wave centers, since electrons should have been proven in phase two.



- If the *Electron Count in Simulation* is set to 0, then only wave centers are placed randomly into the simulation.
- If the *Electron Count in Simulation* is 1 or more, then electrons are randomly placed into the simulation using the electron properties (number and geometric configuration) found in phase two. They should be randomly placed, regardless of standing wave position node.

Why? *Injecting electrons initially into the simulation saves the program time to reach this step. By randomly placing electrons, a mix of electrons and positrons should naturally occur as the only difference is node position in a wave.*

3.3 Initial Wave Amplitude

The *Spacetime Initial Amplitude* should be adjusted with higher energy than phase two. Significantly more energy is required to merge standalone particles together to form composite particles, yet the rule of stability remains the same. Wave centers move to minimize amplitude (energy) and are stable at standing wave nodes. This includes standalone particles that consist of wave centers.

It may need to be increased until the velocity of electrons in the simulation are nearly the speed of light (c). This is the expected velocity to overcome repelling, electric forces and locate at standing wave nodes.

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 electron's diameter is set to 40 meters as the baseline for scaling.
2. The alternative method from 3.2 to randomly inject electrons to the simulation was chosen. An option for both electrons and positrons has been set in the UI.
3. The External Force has an adjustable setting to match the requirements in 3.3, using force instead of amplitude. In addition, a separate option for setting a force of a colliding particle has been added as a Particle Accelerator force.

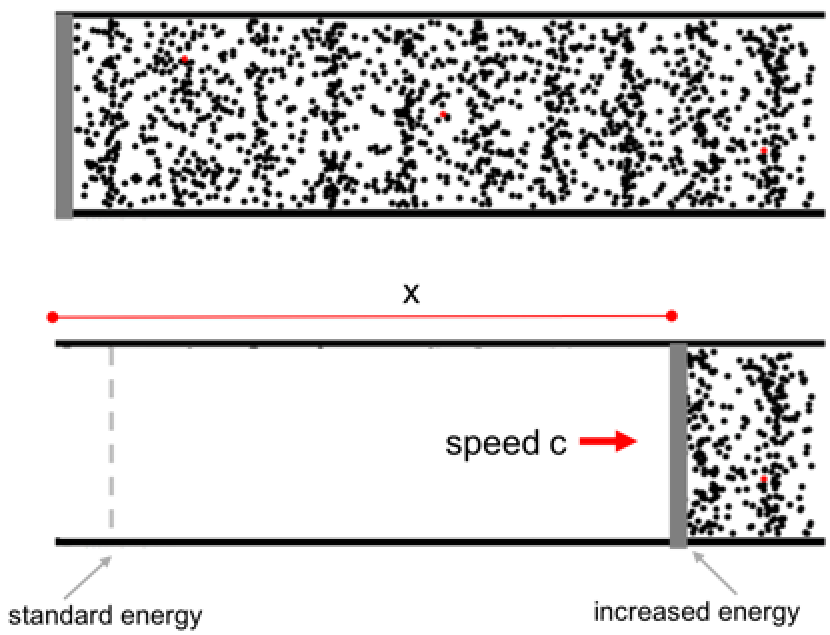
Runtime

Some of the known composite particles, including mesons, baryons, tetraquarks and pentaquarks should begin to appear in this phase at runtime. These particles are formed from quark arrangements, with two, three four and five quarks in arrangement for each particle, respectively for the aforementioned composite particles. The notable composite particles that should appear in this phase are the proton and neutron.

3.4 Inject Additional Energy

Additional energy should be injected into the universe to form composite particles. It is likely that the **proton will not form without significant energy**. It is expected that composite particles will be created from high-energy electrons and positrons, which is why the initial conditions from this section are mandatory before runtime. Initial calculations show that electrons need to be moving at nearly the speed of light to overcome repelling electric forces and merge, and furthermore, that four electrons must merge within each particle's standing waves at nodes at roughly the same time to be stable, otherwise the composite particle quickly decays.

Similar to phase two, an initial longitudinal wave amplitude (A_l) is set. It then decreases from the *Spacetime Initial Amplitude* to the *Spacetime Amplitude* over the time defined by the *Time to Amplitude* property (in seconds).



This energy may be replicating energy levels seen in the early universe when protons formed. It is difficult to predict the exact energy required for proton formation, thus this step may need to be iterated upon until electrons and positrons accelerate to extreme velocities and merge to become quarks and form composite particles.

Why? *Nucleons are not created in standard conditions today. A proton may decay to a neutron or vice versa, but not the creation of a nucleon itself. Speeds such as high-energy* *particle accelerators, or perhaps early conditions in the universe, may lead to the creation of nucleons.*

3.5 Physics of Motion

The physics of particle motion and the creation of composite particles is identical to previous phases. Wave centers move to minimize amplitude, attracting or repelling particles based on constructive or destructive interference of traveling waves, or creating stable positions at zero-amplitude nodes of standing waves. In this phase, particles now interact not only with longitudinal waves, but also transverse waves created from the spin of the electron and positron.

Particle Combination

At the start of runtime, electrons and positrons may be randomly placed into the simulation and tracked for motion (refer to initial conditions where this may be set, or extended from phase two where they naturally occur over time).

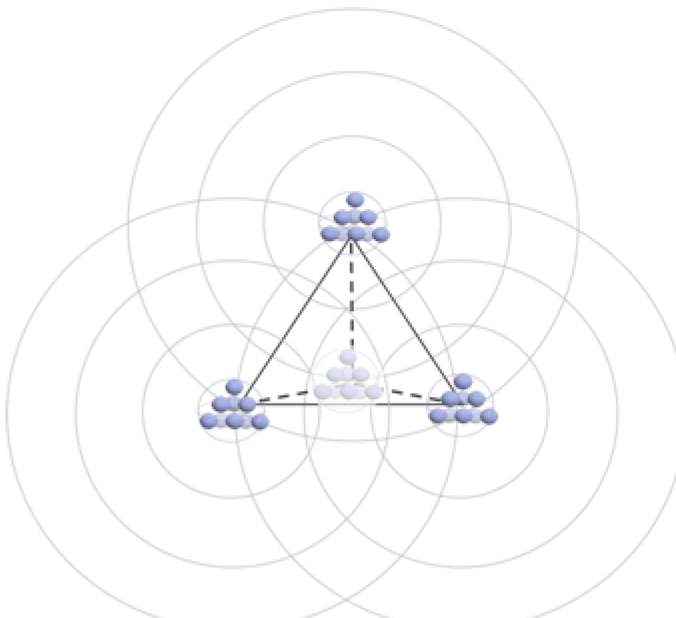
From the physics established in phase one, particles motion should be in the direction of minimal wave amplitude (energy). Due to the standing wave node position of particles, the electron and positron should create destructive wave interference and be attractive. Two same-charge particles, such as two electrons, will be repulsive due to constructive wave interference. This should have been validated in phase two. In this phase, the electric force of two electrons (or two positrons) may be overcome as energy is increased.

When an electron increases velocity, it gains energy, as found in Einstein's special relativity. If there is sufficient energy to overcome the repulsive force of another electron and it reaches a standing wave node for stability, this energy is stored and the electron should appear as a higher-energy quark. A single electron in these conditions should be a quark, although only occurring in the presence of one or more other particles where it resides at a standing wave node. The following are the number of combinations of electrons and positrons as they collide and the types of composite particles that they create:

- 2 – mesons
- 3 – baryons

- 4 – tetraquarks
- 5 – pentaquarks
- 6 – sextaquarks

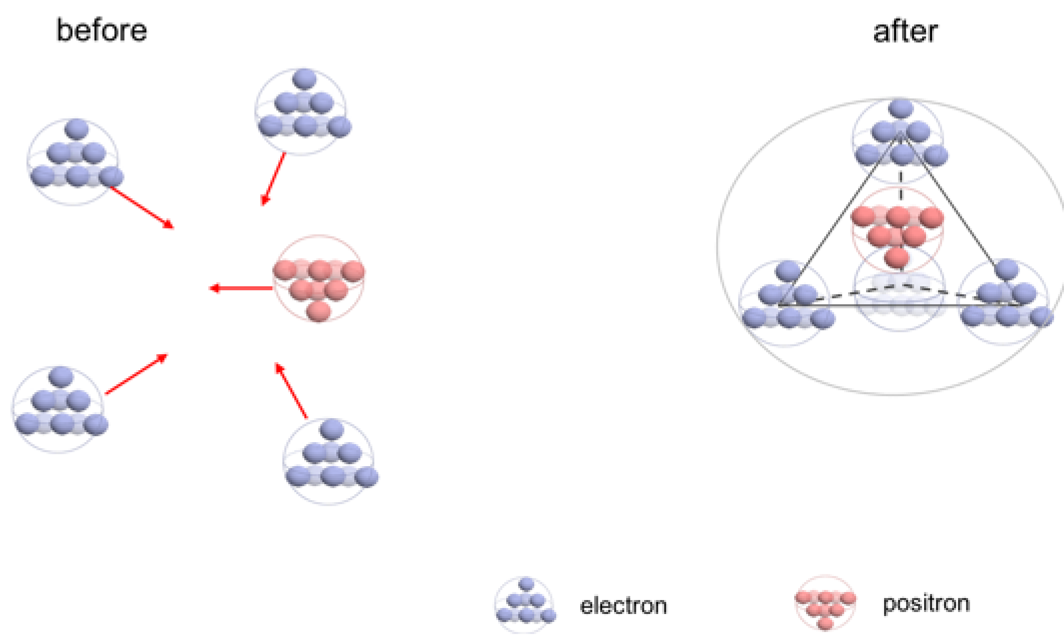
Stable particles should be able to merge with others, very similar to the way wave centers merge to create stable particles. The same rules apply, but now standalone particles combine to create composite particles. It is the same rule that wave centers may be stable at standing wave nodes, although more energy is required to get particles to merge. The next figure illustrates spherical longitudinal standing waves as circles, where the intersecting points are stable standing wave nodes in a three-dimensional arrangement.



Similar to phase two, particles form and decay as there are only certain combinations and geometries that allow wave centers to be stable at standing wave nodes. During runtime, these particles may form and then decay to smaller combinations of particles. This can be tracked and the time duration that the particles were in combination may be stored and validated against known particle decay times.

Proton Formation

The combination of four electrons and a positron forming a pentaquark is expected to be the structure of the proton. A combination of their antimatter equivalents – four positrons and an electron – would form an antiproton. A proton is not formed under these conditions on Earth today, thus it is expected to occur only at significantly high energies, which may have been possible in the early universe. The *Spacetime Initial Amplitude* from the initial conditions will need to be iterated upon until the proton forms, since this energy value is not known. The runtime should track when a proton is created and report on its components (number of electrons and positrons) and their position in the composite structure.



Composite particle creation

Neutron Formation

A neutron should form after the creation of the proton. A standalone neutron decays when not bound in an atomic nucleus. Thus, the proton should appear first. The neutron should be a proton with an additional electron in the center of the structure such that it causes destructive wave interference with the proton, resulting in its neutral charge. The center electron will not be stable unless bound with a proton, so the neutron should be monitored at runtime for its time to decay.

Why? *The proton and neutron are known composite particles, but thought to be made of quarks. Yet quarks don't appear in nature, and are therefore likely high-energy versions of known, stable particles… like the electron. In fact, electrons and positrons are what appear in beta decay results of protons and neutrons, further validating this concept.*

Blender Add-On Modifications

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

1. A Lennard Jones force in Blender has been used for particles at short ranges, replacing the charge force when they combine at these distances. This is a good approximation for strong forces, but there should ultimately be one force that is based standing vs traveling waves.
2. Like Phase 2, the proton has a 1/2 spin, but it uses Blender keyframe animation.
3. A particle accelerator option has been added to illustrate beta decay and particle collision experiments.

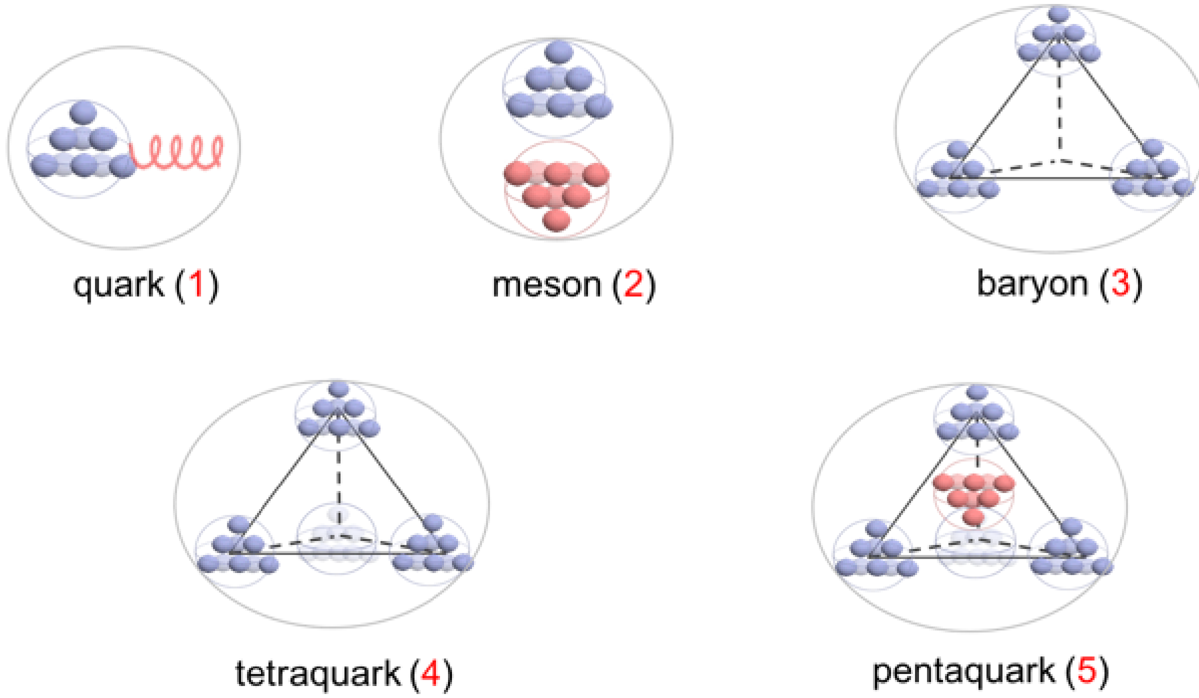
The issue with the creation of standing waves and particle spin are documented in the ReadMe file.

Validation

The following should be validated during the simulation.

3.6 Formation of Composite Particles

During runtime, many formations of particles may occur as random events as electrons and positrons (standalone particles) collide. Some will be relatively stable and others may occur quickly and decay to a smaller number of particles. When a formation of two or more standalone particles collide, it should be visually recognized in the computer simulation.



The following information should be recorded when a composite particle is detected:

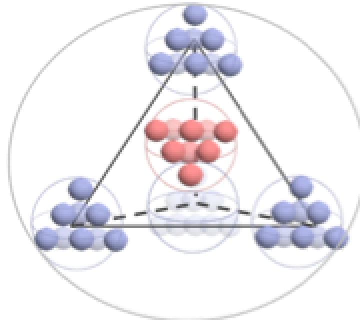
1. The type of composite particle (e.g. meson, baryon, etc)
2. The number and type of electrons and positrons and their arrangement
3. The time from creation to decay of the composite particle

Validation (Optional)

Decay times may be validated against known proton collision experiments for various particles.

3.7 Formation of the Proton

The proton should be a pentaquark structure validated in the previous section. It should be stable and not decay within the runtime.



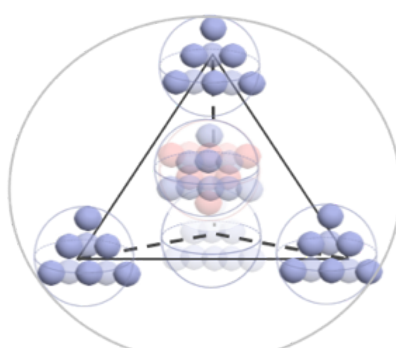
Validation

The proton's energy may be difficult to calculate, but it needs to be validated as it is a critical particle for future phases of the project. The ideal method for calculation would be *after* the proton has formed, by calculating the longitudinal and transverse wave energy within the proton's standing wave boundary. An alternative method, if this is difficult for a simulation, is to calculate the energy of its components *immediately before* the proton has formed. Assuming the proton is a pentaquark, the relativistic energies of four electrons (using the electron's energy, velocity and Lorentz factor) just before being stored in the proton can be added to the rest energy of one positron to be the assumed energy of the proton. The **proton's energy (E_p)** should be validated to be roughly:

Validate: $E_p \approx 1.5 \times 10^{-10}$ joules (kg m^2/s^2)

3.8 Formation of the Neutron

The neutron should be a structure similar to the proton but with an additional electron in the center. It should be stable when paired with a proton forming an atomic nucleus, but should decay to be a proton if alone.



Validation

The neutron's energy may be difficult to calculate, similar to the proton. The same method used for the proton, either calculating the energy *after* it has formed or the energy of each of its components *immediately before* the neutron forms may be used. If the latter, the relativistic energies of four electrons (using the electron's energy, velocity and Lorentz factor) just before being stored in the proton can be added to the rest energy of one positron and one electron to be the assumed energy of the neutron. The **neutron's energy (E_n)** should be nearly the same as the proton's energy with the exception of the additional electron, which is negligible for this level of accuracy:

Validate: $E_n \approx 1.5 \times 10^{-10}$ joules (kg m^2/s^2)

3.9 Detection of Strong Force

The strong force should occur between two electrons within their standing wave boundaries, only occurring when within this distance, and likely as a transverse wave between two particles.

Validation

The **strong force (F_s)** measured between two electrons, separated at a distance (r), should be the following:

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

Where:

- μ_0 – the magnetic constant

- q_P – the Planck charge
- α_e – the fine structure constant
- c – the speed of light

This force should be validated. Its relative strength can be compared against the electric force, from phase 2. The relative strength of the electric force to the strong force should equal the fine structure constant.

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

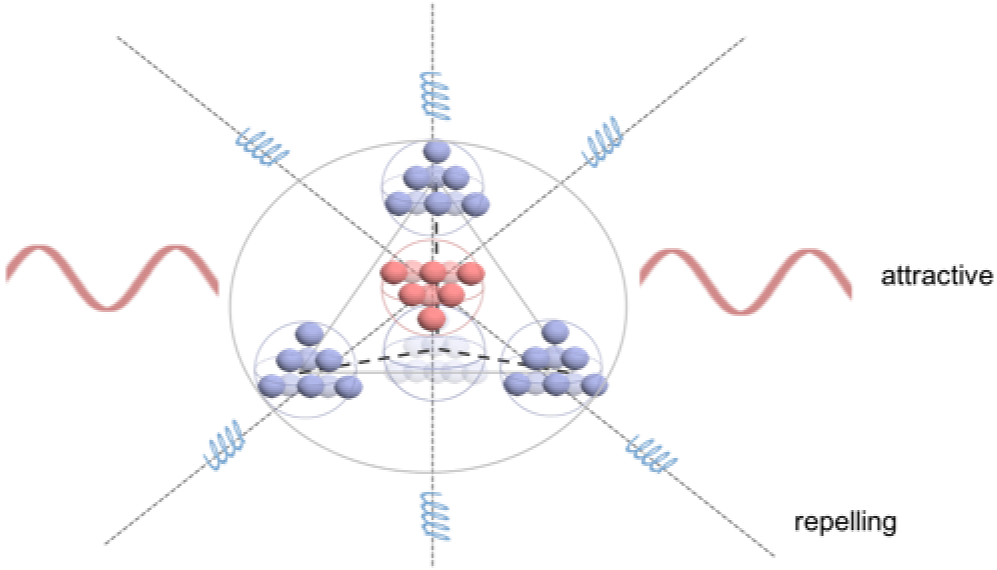
The strong force should **only appear** when the distance (r) is less than the electron's classical radius (r_e), because stability is within standing waves. Furthermore, the only stable position within standing waves is at a standing wave node. The strong force equation is **only valid when at the node** – and varies in strength at other times.

Note: *The equation can also be used for the nuclear force (separating nucleons within an atomic nucleus) as it is the same principle, but now with electrons separated at a larger distance and placed at a further standing wave node.*

3.10 Detection of Magnetic Force of Orbitals

The structure of the proton should have both attractive and repelling forces, with the spherical attractive force dependent on the square of distance, and a repulsive magnetic force dependent on the cube of distance. The latter is seen in static magnets. In a single proton, it is the cause of electron orbitals and will be used to create atoms in the next phase.

The magnetic dipole force along the axis between the positron and an electron (quarks), or possibly between two electrons, should be repulsive only along this axis.



Proton – attractive and repelling forces

Why? *The electron does not annihilate with the proton, like it does with a positron. This is likely due to a second force that keeps an electron in orbit and will be validated in the next phase.*

Validation

The **electric force (F_e)** should be validated coming from the proton as its positive charge. The equation is found in phase two.

A new, **magnetic force** responsible for **orbitals (F_o)** should be validated coming from the proton, although it will only be at dipole alignment. The force should be validated at various distances from the proton (r), and should match the force of the following equation:

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

Where, the constants from the above equation are found in the previous section in addition to:

- r_e – the electron's classical radius

Note: the previous equation for dipole magnetism can be derived from the monopole magnetism equation from phase two and a ratio of the electron's radius and distance, as follows:

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

Blender Add-On Validation

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

1. Particle decay time. Any arrangement with 5 electrons or less is stable while more is not. It is an issue with the way the Lennard Jones force is used instead of standing waves nodes.
2. Proton and neutron energies. While the proton and neutron do form, most of their energy is in the form of the gluons that connects these particles, which is not possible to calculate until transverse wave energy can be calculated (from Phase 1).
3. Strong and magnetic forces calculations. The Lennard Jones force is used to attract and repel particles based on distance, which ultimately needs to be replaced with longitudinal standing waves and transverse waves which can be calculated for their forces.

Video Summary

Simulating Nucleons - EWT Project Phase 3

Previous: Simulating Standalone Particles **Next: Simulating Atoms**