Understanding Energy

What is Energy?

The formal definition of energy as given by all physics text books is the ability of an entity to do work. Then one may ask.

What is work?

To answer this question, and subsequently, what is energy, one needs only to look at what happens in the physical world regarding all entities that requires these entities to do something other than do nothing. Entities require something to make them move, change their shape or form, or from one state of matter to another. Eg from a solid to a liquid to a gas.

This something can be expressed as a gradient of a certain physical property, and in the case of most of mechanical work, this is temperature. Temperature gradients are in essence, a difference of the energy of motion of matter in one region of space to that of another, and that the motion of matter is from the higher region of energy (higher temperature) to that of a lower region. As the movement of matter proceeds, that movement of matter changes the energy state of the system as a whole, and this changing of energy state is observed to be so as to have the energy of the system become equal in all regions and thus have an energy gradient of zero.

The total energy of the merged system does not change, only that there is no overall difference in the distribution of that energy.

Similarly in the case of a battery connected in an electrical circuit. A flow of electrical charge from the anode to the cathode is the physical process of the system to reduce an electrical gradient of charge to be zero.

This is what it means for a physical system to do work.

Physical systems that have no energy gradient still have energy existing within them, and this energy can be of any magnitude, but no work can be performed because there is no energy gradient between regions of space for the energy of one region to be transmitted, or flow, into another region, and hence do work. Such physical systems or regions of equal energy where no work processes are present can be referred to as having potential energy. That is, energy that is present and can be released as work if an energy gradient is present. The total potential energy can be defined as the maximum energy gradient that can be defined for that physical system.

A better definition of energy that can be better understood is to say that energy is

Definition E1 : Energy is the “substrate” that causes the change of the physical state of an entity from one physical state A to another physical state B.

That is fundamentally what is happening in any physical process that causes a change in the physical state of an entity. One example of a body or elementary particle will not move or change its direction of movement unless a “something” interacts with it. One case is that of another colliding particle or body, or a field such as an electric or gravitational field.

Thus the colliding body or field is the “substrate” given in **Definition E1** that causes a change in the physical state of the body given in the example above. However, as any physicist or student of physics knows, any interacting entities or bodies do not have the interaction occurring in a one way direction. Any interaction of one body on another also has an interaction upon itself caused by the body it is interacting on.(Newtons 3rd Law)

To go back to the above example, If body B changes its physical state of motion by having body A interact with it by a collision, then body A also interacts with body B to change its physical state of motion. In the case of a field such as gravity, for both bodies to interact with each other, they both must possess the same field. Taking gravity as an example, the gravitational field of Body A interacts with the gravitational field of body B as “seen” by body A perspective, and the reverse from body B perspective.

Thus it is not body A or body B, or any field they may have that causes any change in either of their physical states, it is the interaction itself that causes these changes.

Therefore the “substrate” of **Definition E1** is not a physical property that makes up energy, but it is the interaction of one physical property of an entity A with that of another entity B that can be defined as the source of the energy. It can be considered that the interacting property that is the source of energy is of a common like type. Eg. electromagnetic fields interact with other electromagnetic fields. **Definition E1** can be better stated as

Definition E2 : Energy is the interaction of physical properties of one entity, or a system of entities with another entity or system of entities that causes the change in the physical state of all entities involved from one physical state A to another physical state B.

When speaking of energy, many a physicist will coin the term “Energy can be transferred from one form of energy

into another”

What does this mean?

The are many terms for energy. Electrical, chemical, nuclear, gravitational, thermal, mechanical and kinetic energy to name some of the most common. Do they all have something that is fundamentally in common to all of them that complies with definition E2, and facilitates the term for the transference of one energy into another?

To answer this, it is best to consider the fundamental entities in the universe, the electron and proton. Each possess an electric and gravitational field which can interact with each other forming much of known matter in the universe. Even more fundamental is electromagnetic radiation in the form of photons, of which the interaction of two like photons with the right properties of what is termed wavelength or frequency, can create an electron-positron pair. This is a reverse process where combining an electron-positron pair will result in two photons of the same wavelength that created the electron-positron pair.

This satisfies **Definition E2**, and thus electromagnetic radiation is one of the most fundamental forms of energy that is common to all forms of matter. This fundamental form of energy can defined by what is measured as the wavelength or frequency of this EM radiation or photons, also called light. When examined, the forms of energy mentioned can be broken down to the interaction of photons with the matter, or the interaction of the electric and gravitational fields matter possess, with each other.

A really simple definition of energy could be stated as thus.

Definition E3 : Energy is what causes a change in an entity or system of entities to change form an initial physical state A to another physical state B.

Potential Energy

Physical entities or systems of physical entities that are in equilibrium have, as discussed above, a potential energy that is available in that entity or physical system that can be utilised to change the physical state of an entity or physical system, which is to perform work. A definition of this potential energy can be stated as.

Definition E4 : Potential energy is the energy that is present and can be released as work if an energy gradient is present. The total potential energy of an entity or physical system can be defined as the maximum energy gradient that can be defined for that physical system.

What this means is that even with an extremely high potential energy for a particular physical entity or physical system A exists, if the energy gradient that exists between it and a secondary entity or physical system B is less than that the total potential energy, then only the energy equal to this energy gradient will be released to equalise the total energy of the physical system, and thus change the physical system state to one of where no work can be performed.

However, in many physical processes, the process of energy transfer does not always follow a process of energy equalisation. Energy transfer in quantum processes require energy to be transferred as a quantised quantity, and thus in some processes, unless an exact quantity of energy is available, energy is either not exchanged, or only a certain quantity is exchanged. In some processes, it may be that even for an energy gradient less than that of the potential energy of an interacting entity or physical system, the entire potential energy of the interacting entity or physical system A is transferred to the entity or physical system B as outlined above.

Such differences in physical processes of energy interaction or transfer can be attributed in context to the scale of the physical entity or system. On the macro level, where it is the statistical mathematical treatment of measured values that give an average value of energy gradients over a volume that is many magnitudes of order greater that the individual entities or components that make up that physical system (eg gas molecules), a physical behaviour of energy seeking an equilibrium of zero gradient applies, and can be achieved.

However, on a smaller and smaller scale, this seeking of an equilibrium of zero energy gradient may exist, but can not be achieved as the interpreted particles and molecules etc that constitute the structure of a physical system of matter cannot bind together their energy gradients into a single substance. Thus they fluctuate continuously interacting with each other exchanging energies, and creating at a certain scale gradients of energy in which interactions are of an endless physical process of seeking to reach energy equilibrium.

Energy and forces

When considering energy as defined by **Definition E3**, it is defined commonly in physics that to change the physical state of an entity, such as the direction of motion or velocity, a force is exerted on the entity. Gravity, or an electric force for example. Thus energy can be considered as another expression or definition of a force, and from **Definition E2**, a force can be defined as the interaction of energy fields, where those energy fields on the most basic level are gravitational, electromagnetic or nuclear.

If there is a unification of these fields into one grand unified field theory that is sought by physicists, then a fundamental process of thinking to unify these fields would be to consider that they all interact with each other in a

fundamental way, and that they are all manifestations of a single field, and hence energy source.

Such forces can be considered as an interaction of energy gradients in space seeking to equalise the energy gradients into a single zero energy gradient state. Electromagnetism seems to be able to achieve this through particle-anti particle annihilation, and matter with mass through gravitational attraction. Considering forces as a kind of interaction of energy gradients, energy gradients have a direction of that gradient from that of a higher state of energy to that of a lower energy state. Thus if forces are to be considered as an expression of energy, that expression of energy is one of the direction at which that energy changes, and the magnitude of that change. Force can thus be thought of as a vector expression of the change of energy, or the direction of an energy gradient or interaction from a high state of energy to that of a low state of energy.

The example of a gravitational potential energy is that the two motionless masses relative to each other interact with each other have a potential energy of interaction according to their masses and separation from on another. This potential energy is a gradient of gravitational energy that exists between them. The gravitational interaction between these entities results in a motion of each mass towards each other as a result of gravitational energy being given up and converted into the kinetic energy of motion of each entity towards each other. When the two entities meet, they have zero potential gravitational energy, and only kinetic energy.

What is commonly referred to as a gravitational force causing the motion of masses can be thus also be thought of as a direction of gravitational energy of interaction of the gravitational fields of the mass properties of both entities.

Energy of Medium Displacement or Waves

In many a discussion of waves within a medium such as water or a string, the waves are often described as an oscillating displacement of the medium, with the transmission of energy in the direction of the displacement, and the energy of the wave in the amplitude of the displacement. However the basis of the mechanics of this wave-energy is not always discussed in detail.

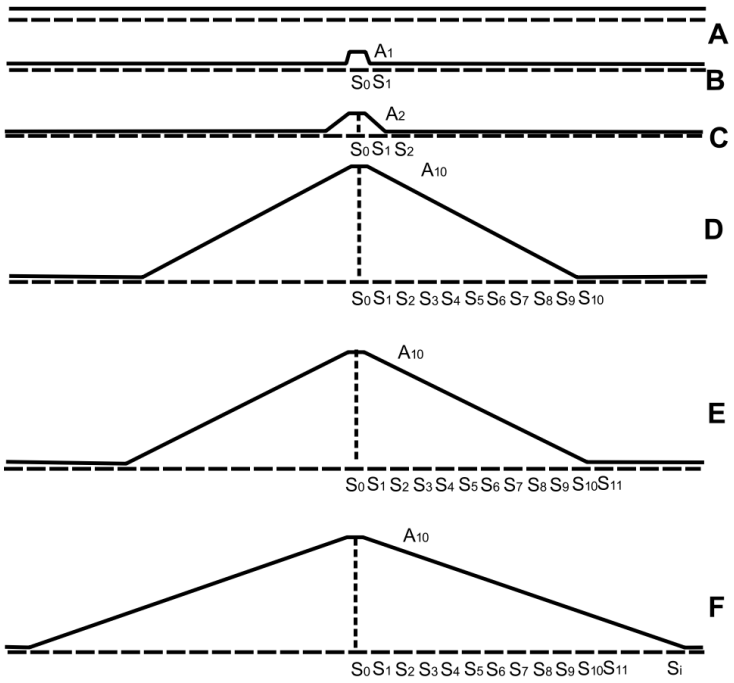

FIG E01

Consider a medium of a one dimensional string. Consider that this one dimensional string has a zero energy state where it is flat and undisturbed (**Fig E01A**). Consider that this string consists of a structure of many tiny segments of sub strings all bound together at their boundaries and are considered to be at a zero energy state when undisturbed and at a minimum length. Consider that the boundaries of these sub strings has elastic properties that act like springs and act to return any disturbance from its flat zero energy state back to this zero energy state.

Consider a disturbance of this one dimensional string at a segment s in the string (**Fig E01B**) that occurs with a magnitude or amplitude A_1. Consider that this disturbance of string segment s has a reaction, that is, interaction with the string segments on either side of it in an iteration period of Δt_s. Consider that the string segment s_0 continues to increase in its disturbance for each iteration period until if reaches a maximum disturbance amplitude A_{10} after ten iteration periods.(**Fig E01D**) For each ith iteration period i string segments on either side of the so

segment undergoes a process of interaction increasing their disturbance away from their zero state. At ten iteration periods, 10 string segments are displaced either side of s in equal heights from the base zero energy state of the string segments to the amplitude A_{10}.

Consider that the string segment s remains at the amplitude A_{10}, then the string segments s_{10} that has the s_{11} string segment as a neighbor that is in the zero energy state, (**Fig E01C**) interacts with the s_{11} string segments in iteration period t_{11}. This interaction increases the energy of the s_{11} string segment, and also increasing the length or distance of the total displacement of the space medium from its zero energy state. For each i iteration period, each of i string segments either side of the s_0 string segment undergoes this same interaction causing a disturbance of the i string segment away from its zero energy state. (**Fig E01D**)

This can be considered to be a propagation of the disturbance of the string from its zero or natural physical state. Such a disturbance can be considered as the disturbance of energy state of the string from its natural zero energy state. Such a disturbance and propagation of it can be considered as a wave of energy that is transmitted away from the central string segment source of displacement, s_0.

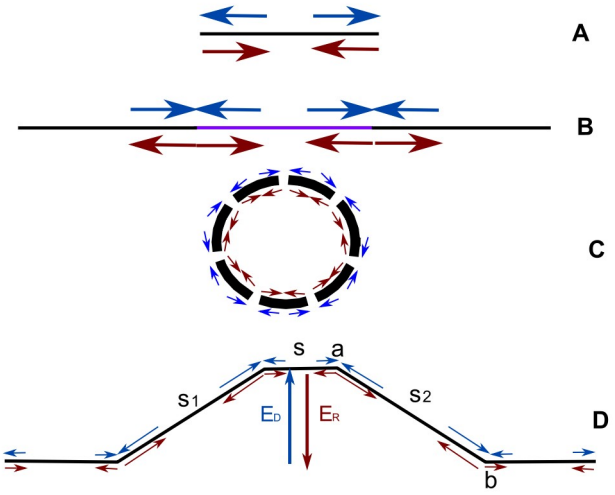

FIG E02

If there is a consideration given to this disturbance of such a string as described and depicted by **FIG E01,** the physics of such a system needs to be taken into consideration by real world observation. The energy of this string system is stored in the tension of the string, and each sub string has a tension on each side of the sub string that connects and interacts with its sub string neighbors.(blue arrows of **Fig E02 A**) This tension is an interaction force that acts to deform the sub string by increasing its length. Countering this is an intrinsic inner force that acts to maintain the sub string physical state of its length (red arrows of **Fig E02 A**). Considering that force is an expression of energy, these forces acting upon each sub string of a string is a form of an energy state of each sub string, and the string as an entity.

Consider that a string is in its neutral zero energy state of being not deformed and consists of n sub strings that form a straight line (**Fig E02 B**) The sub strings interact with each of its neighbors so as to form the total string entity, and this interaction creates a tension at each location of interaction. At each location of interaction, each sub string has a counter restoring force or energy that acts against this tension keeping the sub string physical state of its length constant. Consider that this restoration energy or force is enacted only upon an interaction that induces a tension in the sub string. A kind of elastic force and energy that can have potential energy available to be used much greater than that of the natural non deformed tension energy state. If it is considered that these tension and restoration forces are of equal magnitude, then the net energies and forces at the interaction nodes is zero. Adding all these forces of energies together gives a net result of zero tension and zero internal restoration force. No interactions occur at the ends, so not tension or restoration forces, and energies are present.

If it is considered that a string is in the form of a loop, all sub string segments would have two neighbors to interact with, and for the same reasons described in the above paragraph for a string of zero deformation, all sub strings would have a net energy state of zero. (**Fig E02 C**)

Consider that these zero energy tension forces are of an energy value ET0, and that each sub string has an available restoration potential energy of a value ERPE that can be much greater than ET0.

Consider that an interaction node of a sub string is deformed, the total tension on this interaction node is greater than ET0. This tension resulting from the deformation of the interaction node is enacted by an external additional energy ED interacting with the sub string changing its interacting nodes location or physical state such that it changes the sub strings length from its natural zero state by enlarging it.(**Fig E02 D**). The sub string restoration energy, ER, (that is interpreted as a force) begins to act by resisting the deformation. Consider that the restoration force is constant and exists for all periods of iteration of time. The restoration force and energy is thus permanent

and inexhaustible, whereas unless the energy causing the deformation is also permanent and inexhaustible, the restoration force and energy will restore the sub string segment to its natural zero energy state once the deformation interaction is completed.

Such a restoration energy can be thought of as analogous in principle to that of a spring or elastic band.

In **Fig E02 D**, it can be seen that the restoration forces (red) are acting within each of the sub strings, in an effort (ie work) to restore them back to their natural net zero energy state. For a deformation of a sub string segment S in **Fig E02**, the neighbor sub strings on both sides that interact with S are S1 and S2, which are deformed in their lengths. The energy ED interacts with S causing the S tension forces at the interacting nodes to increase and deform the neighbor sub strings S1 and S2 by lengthening them. S may also deform by having its length increase.

Consider that the deformation ED energy is less than the net restoration energy ER of the string. The restoration energy acts to restore the sub string elements to their neutral zero energy state. However, if the deformation energy E_D is sufficient to act against this restoration energy E_R so as to be equal to its action, a stable physical state of deformation is achieved and the situation described above in regards to **FIG E01** is present. If the deformation energy E_D is large enough the such that the tension energy E_T at the interacting nodes of the sub string S exceeds the restoration energy E_R, then it can be considered that a situation exists for the destruction of the string at one or both of these interacting sub strings, creating a situation of the string being cut at this location.

Consider a situation where the deformation energy applied to any sub string S a string is variable, and does not exceed at any instant the restoring forces of any sub string. Such a variable deformation situation is illustrated in **FIG E03**, where only one side of the deformation is displayed as such deformations would be symmetric from a given location of deformation.

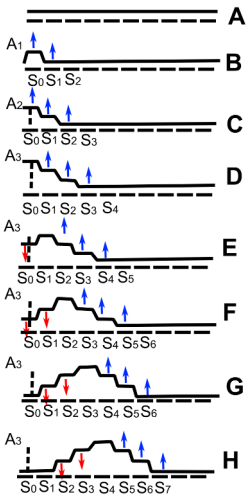

FIG E03

No string deformation is present in **FIG E03 A** and have a flat straight line.

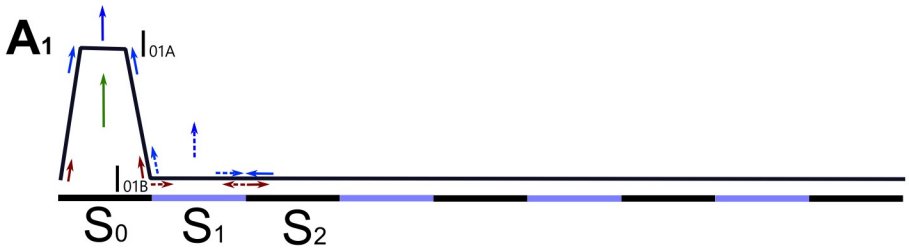

FIG E04B

In an iteration of period T1, the string is deformed at a sub string S0 at an amplitude of A1. The interaction of this sub string with its neighbors is not instantaneous and results in a delay in the deformation of neighbor sub string S1. However there is a net tension force on S1 that develops as a result of the interaction of its boundary with S0 that is in the direction of the deformation.(**FIG E03 B**).

Illustrated in **Fig E04B** is a depiction of the interaction between S0 and S1. The arrows indicate the energies or forces of this interaction. The line from I01A to I01B represents the lengthened or deformed section of the string S0. The blue arrows, the tension energy forces, and the red arrows, the restoration energy forces. The energy that distorted the sub string segment S0, in effect, changes the direction of the tension energy of S0 where S0 interacts with S1, to be in the direction of the distortion. That is in an upward direction. During this interaction, the direction of

the tension energy force of S1 with S0 changes to match the direction of the distortion. This, added to the tension energy force of S1 interacting with S2 has a net tension force for S1 being in the upwards direction. The direction of the restoration forces maintain a direction so as to counter these tension forces so as to maintain a natural zero energy state (ie flat undisturbed) of the string.

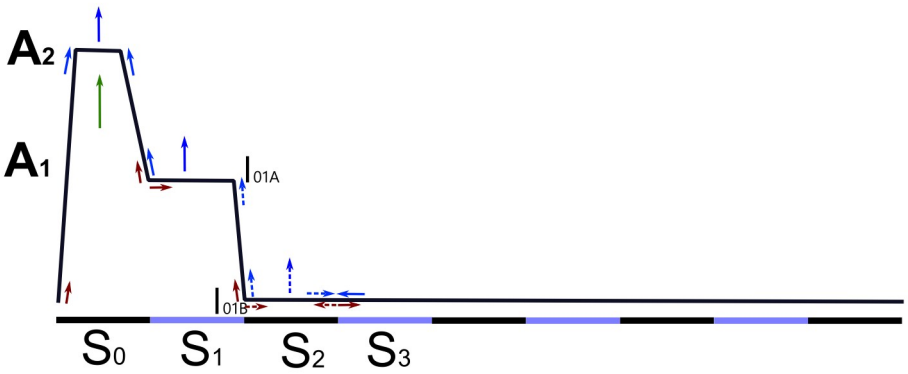

FIG E04C

In an iteration of period T2, the string is deformed at a sub string S0 to an altitude of A2. The interaction of sub string S0 with S1 is now in effect and causes S1 to deform in the direction that S0 deforms. The magnitude of this deformation is half the value of amplitude A2 so as to have an equal tension force of S1 with S0, and S1 with S2. (**FIG E03 C**). A net tension force on S2 that develops as a result of the interaction of its boundary with S1 that is in the direction of the deformation, with a delay if this interaction acting on it.

Illustrated in **Fig E04C** is a depiction of the interaction from S0 to S2. The arrows indicate the energies or forces of this interaction. The line from I01A to I01B represents the lengthened or deformed section of the string S1. The blue arrows, the tension energy forces, and the red arrows, the restoration energy forces.

The interaction of the distorted sub string segment S0, in effect, changes the direction of the tension energy of S1 where S1 interacts with S2, to be in the direction of the distortion. That is in an upward direction. During this interaction, the direction of the tension energy force of S2 with S1 changes to match the direction of the distortion. This, added to the tension energy force of S2 interacting with S3 has a net tension force for S2 being in the upwards direction. The direction of the restoration forces maintain a direction so as to counter these tension forces so as to maintain a natural zero energy state (ie flat undisturbed) of the string.

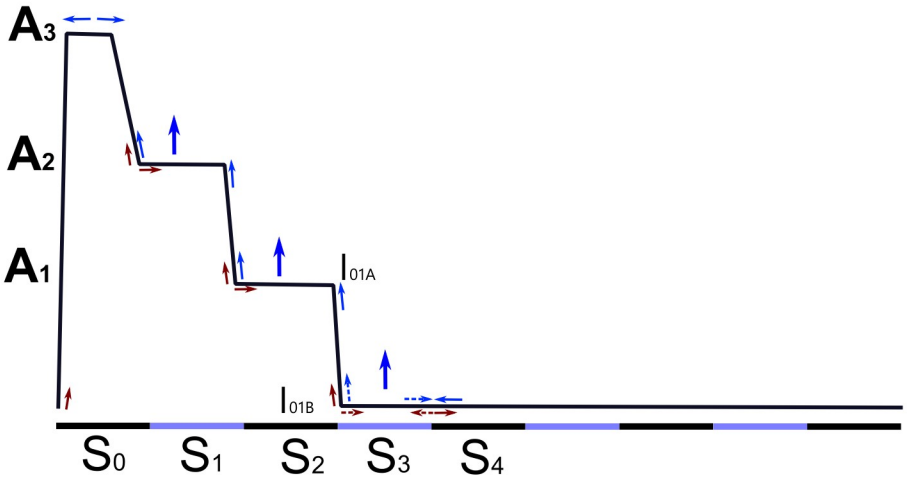

FIG E04D

In an iteration of period T3, the string is deformed at a sub string S0 at an altitude of A3. Within this iteration the force of deformation energy is zero as it has reached its maximum. No more energy is present to continue the deformation of S0 in the upwards direction, which results in the tension energy forces dissipating back to their natural level, and the restoration energy forces at this iteration period to become the dominant forces acting on S0.

The interaction of S0 with its neighbor S1 continues and causes the deformation of S1 to increase to amplitude value A2. The interaction of sub string S3 with S2 is now in effect and causes S3 to deform in the direction that S2 deforms. The sub string S2 undergoes further deformation as a result of its interactions with S1 and with its other

sub string neighbor S3. The sub string S3 is deformed and lengthened as a result of the interactions at the boundary or node of S2 and S4. (**FIG E03 D**)

Illustrated in **Fig E04D** is a depiction of the interaction from S0 to S3. The arrows indicate the energies or forces of this interaction. The line from I01A to I01B represents the lengthened or deformed section of the string S2. The blue arrows, the tension energy forces, and the red arrows, the restoration energy forces. The green arrow depicting the energy applied to distort the string is absent as upon reaching the max amplitude of the distortion, no more distortion energy or force is applied. With no distortion energy present, the tension of the string segment S0 resorts back to its original direction of pointing outwards from the sub string center. The restoration energy forces of sub string S0 become the dominant force at this iteration and begin to act on S0 to bring it back to its undisturbed zero energy state.

There is a delay in the interaction of S0 with S1, and the tension forces governing S1 continues to distort it in the same direction. The tension forces on S2 overcome the restoration forces that results in the distortion of S2 in the direction of the resultant tension energy force.

During this interaction, the direction of the tension energy force of S3 with S2 changes to match the direction of the distortion of S2. This, added to the tension energy force of S3 interacting with S4 has a net tension force for S3 being in the upwards direction. The direction of the restoration forces maintain a direction so as to counter these tension forces so as to maintain a natural zero energy state (ie flat undisturbed) of the string.

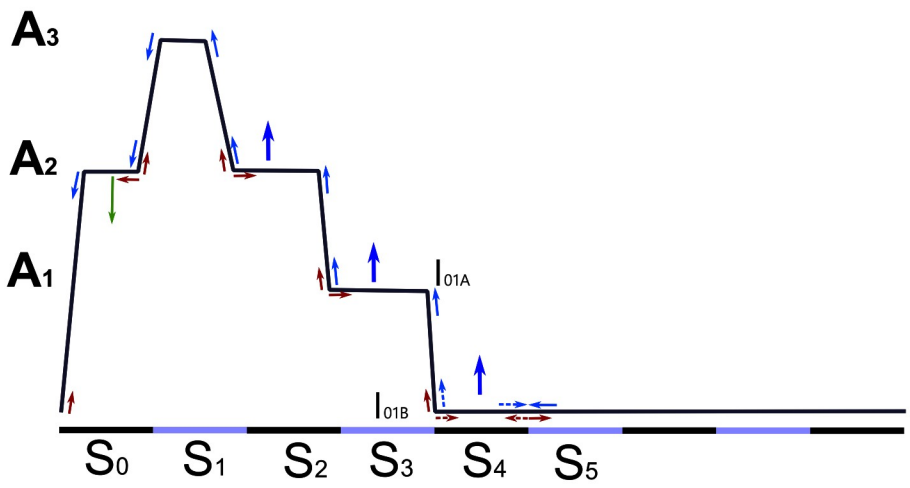

FIG E04E

In an iteration of period T4 (**FIG E03 E**),the sub string S0 has the force of deformation energy reversed into a downward direction, which in effect reverses the direction of tension in the sub string S0 in its interaction with S1. S1 stops its process of deformation as it has its net tension forces interacting with S0 being in a downward direction, and S2 in an upward direction, giving a net zero magnitude force. No more energy is present to continue the deformation of S1 in the upwards direction, as the net tension energy up in its interaction with S2 is countered by the tension energy down in its interaction with S0, and the restoration energy forces at this iteration period to become the dominant forces acting on S1.

Sub strings S2 and S3 continue to deform in the upwards direction towards S1 as the net tension forces on them continue to in this direction. The sub string S4 is deformed and lengthened as a result of the interactions at the boundary or node of S3 and S5.

Illustrated in **Fig E04E** is a depiction of the interaction from S0 to S4. The arrows indicate the energies or forces of this interaction. The line from I01A to I01B represents the lengthened or deformed section of the string S4 The blue arrows, the tension energy forces, and the red arrows, the restoration energy forces.

The green arrow depicting the energy applied to distort the string is in the reverse direction, and in the same direction as the distortion of the sub string S0. This reversal of the distortion energy results in the tension of the string segment S0 going back to its original direction of pointing outwards from the sub string center, but with an additional magnitude added to it from the downward direction of the energy distorting the string. The restoration energy forces of sub string S0 act on S0 to bring it back to its undisturbed zero energy state.

The string segment S1 reaches its highest distortion as there is no longer any tension energy force present to interact with in an upward direction. However, substring S0 in its downwards motion of distortion interacts with S1 and changes the direction of the tension force of S1 interacting with S0 in the same downwards direction as the tension energy forces acting on S0. . The restoration energy forces of sub string S1 become more dominant force

at this iteration as there are no longer any net tension foreces distorting S1 and begin to act on S1 to bring it back to its undisturbed zero energy state.

There is a delay in the interaction of S1 with S2, and the tension forces governing S2 continues to distort it in the same direction. The tension forces on S3 overcome the restoration forces that results in the distortion of S3 in the direction of the resultant tension energy force.

During this interaction, the direction of the tension energy force of S4 with S3 changes to match the direction of the distortion of S3. This, added to the tension energy force of S4 interacting with S5 has a net tension force for S4 being in the upwards direction. The direction of the restoration forces maintain a direction so as to counter these tension forces so as to maintain a natural zero energy state (ie flat undisturbed) of the string.

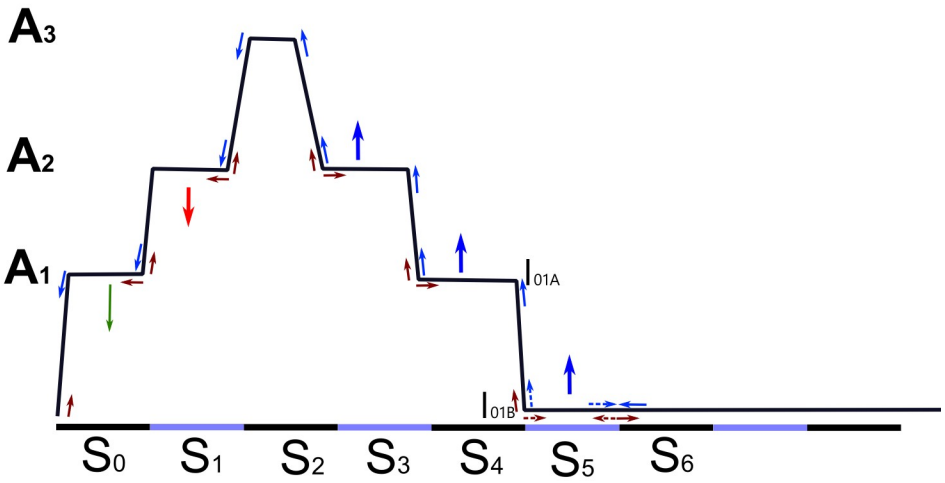

FIG E04F

In an iteration of period T5 (**FIG E03 F**),the sub string S0 continues in its downward the direction as the direction of force energy continues in this direction. As it does, so the direction of the tension in the sub string S0 is also in this direction. S1 moves in the downward direction as the tension forces in interaction with S0 are also in this direction, and the interaction of S1 with S2 at the boundary node of interaction results in a downward direction of tension energy.

S2 stops its process of deformation as it has its net tension forces interacting with S1 being in a downward direction, and S3 in an upward direction, giving a net zero magnitude force. No more energy is present to continue the deformation of S2 in the upwards direction, as the net tension energy up in its interaction with S3 is countered by the tension energy down in its interaction with S1, and the restoration energy forces at this iteration period to become the dominant forces acting on S2.

Sub strings S3 and S4 continue to deform in the upwards direction towards S2 as the net tension forces on them continue to in this direction. The sub string S5 is deformed and lengthened as a result of the interactions at the boundary or node of S4 and S6.

Illustrated in **Fig E04F** is a depiction of the interaction from S0 to S5. The arrows indicate the energies or forces of this interaction. The line from **I01A** to **I01B** represents the lengthened or deformed section of the string S5 The blue arrows, the tension energy forces, and the red arrows, the restoration energy forces.

The sub string S0 continues in its downward motion as the direction of the distortion energy represented by the green arrow continues in this direction towards the undisturbed zero energy state of S0.

The string segment S2 reaches its highest distortion as there is no longer any tension energy force present to interact with in an upward direction. However, substring S1 in its downwards motion of distortion interacts with S2 and changes the direction of the tension force of S2 interacting with S1 in the same downwards direction as the tension energy forces acting on S1. . The restoration energy forces of sub string S2 become more dominant force at this iteration as there are no longer any net tension forces distorting S2 and begin to act on S2 to bring it back to its undisturbed zero energy state.

There is a delay in the interaction of S2 with S3, and the tension forces governing S3 continues to distort it in the same direction. The tension forces on S4 overcome the restoration forces that results in the distortion of S4 in the direction of the resultant tension energy force.

During this interaction, the direction of the tension energy force of S5 with S4 changes to match the direction of the distortion of S4. This, added to the tension energy force of S5 interacting with S6 has a net tension force for S5 being in the upwards direction. The direction of the restoration forces maintain a direction so as to counter these

tension forces so as to maintain a natural zero energy state (ie flat undisturbed) of the string.

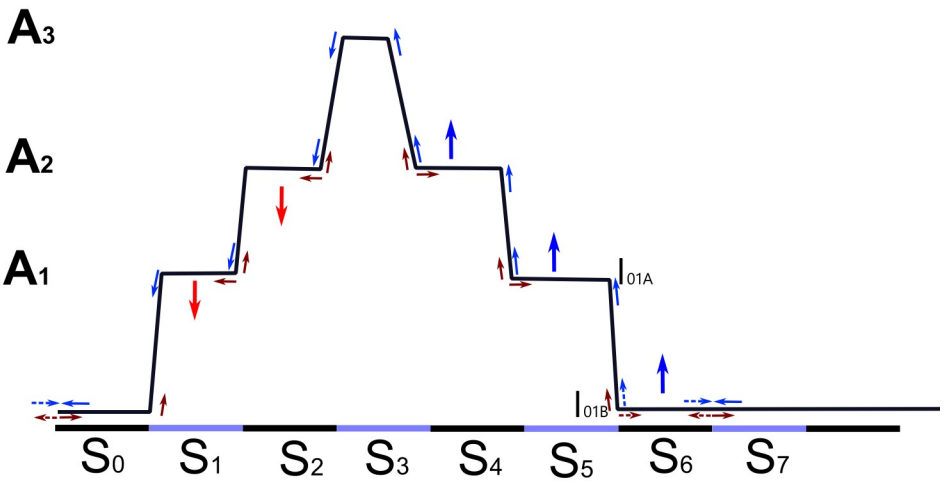

FIG E04G

In an iteration of period T6 (**FIG E03 G**),the sub string S0 reaches it initial zero state, and the force energy of deformation is no longer applied. The interaction with S1 however continues, which continues the tension between S0 and S1 being in a downward direction. S1 continues in the downward direction as the tension forces in interaction with S0 are also in this direction, and the interaction of S1 with S2 at the boundary node of interaction results in a downward direction of tension energy.

S3 stops its process of deformation as it has its net tension forces interacting with S2 being in a downward direction, and S4 in an upward direction, giving a net zero magnitude force. No more energy is present to continue the deformation of S3 in the upwards direction, as the net tension energy up in its interaction with S4 is countered by the tension energy down in its interaction with S2, and the restoration energy forces at this iteration period to become the dominant forces acting on S3.

Sub strings S4 and S5 continue to deform in the upwards direction towards S3 as the net tension forces on them continue to in this direction. The sub string S6 is deformed and lengthened as a result of the interactions at the boundary or node of S5 and S7.

Illustrated in **Fig E04G** is a depiction of the interaction from S0 to S7. The arrows indicate the energies or forces of this interaction. The line from I01A to I01B represents the lengthened or deformed section of the string S6 The blue arrows, the tension energy forces, and the red arrows, the restoration energy forces.

The sub string S0 has completed its downward motion to its zero undisturbed energy state as the distortion energy acting on it has concluded and is no longer acting on it. However, S1 is not in its zero energy undisturbed state, and there is still an interaction with S1 that acts upon both S0 and S1 causing S1 to continue in its motion towards its zero energy undisturbed state.

The string segment S3 reaches its highest distortion as there is no longer any tension energy force present to interact with in an upward direction. However, sub string S2 in its downwards motion of distortion interacts with S3 and changes the direction of the tension force of S3 interacting with S2 in the same downwards direction as the tension energy forces acting on S2. . The restoration energy forces of sub string S3 become more dominant force at this iteration as there are no longer any net tension forces distorting S3 and begin to act on S3 to bring it back to its undisturbed zero energy state.

There is a delay in the interaction of S2 with S3, and the tension forces governing S3 continues to distort it in the same direction. The tension forces on S4 overcome the restoration forces that results in the distortion of S4 in the direction of the resultant tension energy force.

During this interaction, the direction of the tension energy force of S6 with S5 changes to match the direction of the distortion of S5. This, added to the tension energy force of S6 interacting with S7 has a net tension force for S6 being in the upwards direction. The direction of the restoration forces maintain a direction so as to counter these tension forces so as to maintain a natural zero energy state (ie flat undisturbed) of the string.

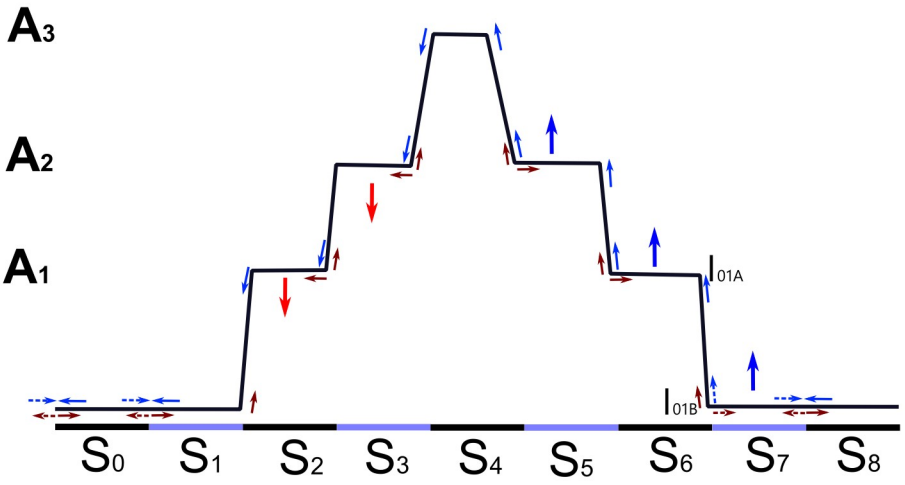

FIG E04H

In an iteration of period T7 (**FIG E03 H**),the sub string S1 reaches it initial zero state, and the force energy of deformation is no longer applied. The interactions with S0 have a net deformation and restoration energy at the boundary of zero as the tension and restoration force energies are of equal magnitude but opposite in direction.

The interaction with S2 however continues, which continues the tension between S1 and S2 being in a downward direction. S2 continues in the downward direction as the tension forces in interaction with S1 are also in this direction, and the interaction of S2 with S3 at the boundary node of interaction results in a downward direction of tension energy.

S4 stops its process of deformation as it has its net tension forces interacting with S3 being in a downward direction, and S5 in an upward direction, giving a net zero magnitude force. No more energy is present to continue the deformation of S4 in the upwards direction, as the net tension energy up in its interaction with S5 is countered by the tension energy down in its interaction with S3, and the restoration energy forces at this iteration period to become the dominant forces acting on S4.

Sub strings S5 and S6 continue to deform in the upwards direction towards S4 as the net tension forces on them continue to in this direction. The sub string S7 is deformed and lengthened as a result of the interactions at the boundary or node of S6 and S8.

Illustrated in **Fig E04H** is a depiction of the interaction from S1 to S8. The arrows indicate the energies or forces of this interaction. The line from **I01A** to **I01B** represents the lengthened or deformed section of the string S6 The blue arrows, the tension energy forces, and the red arrows, the restoration energy forces.

The sub string S0 has returned completely to its undisturbed zero energy sate in all manner of interactions with its neighbors.

The sub string S1 has completed its downward motion to its zero undisturbed energy state and interacting with S0 which influenced its doward motion. However, S2 is not in its zero energy undisturbed state, and there is still an interaction with S2 that acts upon both S1 and S2 causing S2 to continue in its motion towards its zero energy undisturbed state.

The string segment S4 reaches its highest distortion as there is no longer any tension energy force present to interact with in an upward direction. However, sub string S3 in its downwards motion of distortion interacts with S4 and changes the direction of the tension force of S4 interacting with S3 in the same downwards direction as the tension energy forces acting on S3. . The restoration energy forces of sub string S4 become more dominant force at this iteration as there are no longer any net tension forces distorting S4 and begin to act on S4 to bring it back to its undisturbed zero energy state.

There is a delay in the interaction of S3 with S4, and the tension forces governing S4 continues to distort it in the same direction. The tension forces on S6 overcome the restoration forces that results in the distortion of S6 in the direction of the resultant tension energy force.

During this interaction, the direction of the tension energy force of S7 with S6 changes to match the direction of the distortion of S6. This, added to the tension energy force of S7 interacting with S8 has a net tension force for S7 being in the upwards direction. The direction of the restoration forces maintain a direction so as to counter these tension forces so as to maintain a natural zero energy state (ie flat undisturbed) of the string.

The iteration step of period T7 (**FIG E03 H** and **FIG E04H**) is repeated at infinitum from this iteration step onward. What **Fig E03** and the steps described above illustrate are the detailed fundamental principles of a generation of a wave on a string at a fundamental level. It is a perpetual process unless disturbed in a destructive manner that takes the disturbance energy out of the system.

The tension and restoration energy forces involved can have many a mathematical model constructed to distort and restore the string from and back to its undisturbed zero energy state. Most common is a spring like model of stretching and contracting a distortion that follows a simple Hook's law of force

$$F = ky \qquad \textbf{EQ-ES01}$$

where y is the distortion of the spring from its zero undisturbed zero energy state. F is the restoration force to return the spring to its undisturbed zero energy state, and k is a constant of proportionality relating F to y.

However, in all probability, for the case of systems other than that of a simple spring itself, Hooks law expressed by equation **EQ-ES01** would not be relevant. It may be more accurate to express the restoration forces acting on a string as

$$F(i) = k(y_i)\, f(y_i) \qquad \textbf{EQ-ES02}$$

where F(i) is the force of deformation acting on the ith sub string segment, $f(y_i)$ is a function of the disturbance of the ith sub string segment from its undisturbed zero energy state, and $k(y_i)$ the function of proportionality of the ith string segment . **EQ-ES02** resorts back to **EQ-ES01** for $k(y_i) = k$ and $f(y_i) = x$. This leads to an infinite number of possibilities to what form **EQ-ES02** can take.

It is this up to the investigator and modeler of the physical universe to in effect theorise, and reverse engineer $k(y_i)$ and $f(y_i)$, backed up with observation and experiment to determine what k(y) and $f(y)$ are.

Energy of Medium Displacement or Waves In all dimensions

EQ-ES02 is an expression for any entity or physical system that is of, or exists in a one dimensional physical space. The string used as example above represents any one dimensional entity or physical system, and the above discussion can thus be applied for any one dimensional entity or physical system.

For a two dimensional physical space, **EQ-ES02** can be modified to express the forces acting on any 2D surface to disturb a 2D surface from its zero energy state as

$$F(i) = k(x_i,y_i)\, f(x_i,y_i) \qquad \textbf{EQ-ES03}$$

Going further, **EQ-ES02** can be modified to express the forces acting on any 3D surface to disturb a 3D surface from its zero energy state as

$$F(i) = k(x_i,y_i,z_i)\, f(x_i,y_i,z_i) \qquad \textbf{EQ-ES04}$$

But for any 1D,2D, or 3D surface, any disturbance of that surface from its undisturbed, zero energy state would require a space at least one dimension above the space that the surface exists within if that disturbance is considered to be that, like a string, is a one dimensional entity that exists within a two or higher dimensional space, and disturbances from its zero energy state is conducted in a higher dimension. Such an example of this is that of a traversal wave form as described in above in **FIG E03** and **FIG E04B** to **FIG E03H**.This would then suggest that such disturbances in the 3D universe that is observed requires a fourth dimension of space.

If however, it is considered that space is disturbed analogous to that of a longitudinal wave in a medium, then no additional dimension of space is required as the disturbance of a physical entity from its zero energy state is analogous to the disturbance of the volume of space that the entity exists within. Such a disturbance would have the tension and restoring forces represented akin to that of pressure rather than springs in any model of that system that may be formulated. **EQ-ES02** to **EQ-ES03** would more or less be expressions of pressure and not of springs.

Then it may be that to model the universe that humans and matter exist in, the 3D universe that is observed exists within a 4D space, and that disturbances of the 3D space from its zero energy state can be both into this 4D space, and/or also be pressure like. The concepts for both are outlined as above for the one dimensional string representing a region of space interacting with a form of energy to create a disturbance that acts on the internal tension and restoration properties of that space to create a physical behavior or phenomenon such as a wave or even particle of mater.

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The Zero Energy State of Physical Space

In all the discussion of energy and the displacement a physical entity from its zero energy state, that physical entity itself can be considered as existing as space itself. If it is considered that disturbances of that space give rise to what is observed as matter, then that space must have as a premise to exist, a zero energy state of space. Space thus also needs to be a kind of interacting medium of cells that exist in a default zero energy state that is only of a zero value relative to all of other space cells if all have the same energy and there is no difference or gradient of magnitude between any of them. Much like imagining a lake of water that is flat and smooth. And like that lake, the depth represents the total possible energy that the space can posses. That is, a potential energy.

Like a lake, disturbances in the water such as ripples or turbulence represents disturbances of space. Displacements above or below the natural non disturbed flat lake water level represent the disturbances of space above and below its natural non disturbed flat surface of space. This is the best way to picture and understand what the zero energy of space is. The imagining of a lake of water that is flat and smooth, with its depth being the hidden total energy that is available to be disturbed or accessed to return the space to its natural zero energy state.

Model of Spacial Displacement as a wave

In the discussion of energy and the displacement a physical entity from its zero energy state above using a string as an allegory , **EQ-ES02** to **EQ-ES04** gives such a model of space being that of a non continuous medium that is granular or cell like, with each cell having a property of tension in each cells interaction with each cells neighbors, and having an intrinsic internal restoration force to maintain its self. Such a consideration for a model of physical space can then lead to that space having an emergent property of displacement of that space from its zero energy physical state forming a wave.

The wave equation is expressed in its most general form as

$$\frac{\delta^2 u}{\delta t^2} = c^2\left(\frac{\delta^2 u}{\delta x^2}+\frac{\delta^2 u}{\delta y^2}+\frac{\delta^2 u}{\delta z^2}\right) \qquad \textbf{EQ-EW01}$$

or using vector calculus notation is expressed as

$$u_{tt} = c^2\Delta u \qquad \textbf{EQ-EW02}$$

where u_{tt} is the acceleration of displacement of the wave from or towards its zero energy state, c is the velocity of the wave propagation in the medium, and u represents the displacement of the wave from its zero energy state. **EQ-EW02** is similar in construction to **EQ-ES04** where if **EQ-ES04** is expressed as

$$F(i) = m(i)a(i) = k(x_i,y_i,z_i)\, f(x_i,y_i,z_i)$$

where m(i) is the mass if the ith 3D surface element, then have

$$a(i) = \frac{1}{m_i}\, k(x_i,y_i,z_i)\, f(x_i,y_i,z_i)$$

or as expressed in the form of **EQ-EW02** becomes

$$u_{tt}(i) = \frac{k(u_i)}{m_i}\,\Delta u_i \qquad \textbf{EQ-EW03}$$

which implies that for the ith spacial displacement the velocity of wave propagation is

$$c_i = \sqrt{\frac{k(u_i)}{m_i}} \qquad \textbf{EQ-EW04}$$

and **EQ-EW03** for a disturbance of a 3D surface element becomes

$$u_{tt}(i) = c_i^2\,\Delta u_i \qquad \textbf{EQ-EW05}$$

What **EQ-EW04** suggests is that space itself has a component that can be considered as having a form of mass or inertia that inhibits a spacial element to deform from and back it undisturbed zero energy state. The higher the mass element, the slower is the displacement of the 3D surface from its undisturbed zero energy state, and equally, is the restoration of a displacement of the 3D surface back its undisturbed zero energy state

What can also be considered is that the restoration force k, or energy, is the tension of the spacial element in a particular direction that effects the displacement of the 3D surface from and back its undisturbed zero energy state. This tension is considered as the interaction of a spacial cell with its neighbors in a model that has space structured as a matrix of cells. The region of interaction can be considered as a surface of interaction. As the tension or

intensity of interaction increases, so does the restoration of the spacial element back to its undisturbed zero energy state. Consider that as discussed above, to disturb or distort a 3D surface from its zero energy state, energy must be applied to overcome or added to this tension energy force.

Side note : As a curiosity, if **EQ-EW04** is squared obtain

$$c_i^2 = \frac{k(u_i)}{m_i}$$

which becomes

$$k(u_i) = m_i c_i^2$$

which is similar to Einsteins equation $E = mc^2$. If **EQ-EW04** is equivalent to $E = mc^2$, then the tension energy of space described above would be the energy of a rest mass of a particle. Thus tension and restoration energy would then somehow be related to the containment of a region of space into an emergent entity that is known as a particle of matter. This particle of matter can be considered as a stable form of a disturbance of a region of space from its undisturbed zero energy state. What form this stable disturbance of space could be will be left to investigation and speculation elsewhere.

Equation **EQ-EW05** suggests that in the consideration that space itself is a medium, disturbances of that medium being space can be expressed as waves of disturbances. These disturbances of space can be propagated as a wave, and that wave of disturbance of space is a propagation of energy. That disturbance of space then can interact with other disturbances of space and what is considered as matter according to some rules of interaction. These interactions form emergent behaviors that then constitute the laws of physics.

Conclusion

From the above discussion, space may be considered as a structure analogous to that of a fluid or crystal. The waves of distortion that are propagated in that structure are the means of transparency and communication throughout space. Without these waves of disturbances, space would be opaque and static. This can form a basis of a model of the universe. Photons may be waves of energy of a disturbance of the structure of space. This may be interpreted as a hypothesis of the existence of an aether which is largely dismissed as a consequence of the Michelson-Morley experiment.

However, space as may not act or exist as past classical theories of an aether have proposed. If space exists as a kind of structure described above, it may be that the physics and rules involved are alien to observed behaviors of waves observed in fluids and crystals that consist of matter and the interacting forces between them. Space can be considered as energy that has properties and interactions that are different to that observed of matter, and thus any aether that exists would not be thought to behave as any classical physics aether. Thus the Michelson-Morley experiment may have ruled out any classical theory of an aether, but an aether of a different form may exist that forms the backbone and structure of the space of the universe may exist. As has been conjectured and proposed, the space of the universe may be that of a 3D surface existing upon a 4D sphere, and that from this proposal, a 4D space may exist upon which the 3D exists upon, but has not yet been thought of, theorised and tested for.