Building a model of the universe

Mathematics

Iteration

If it is considered that the universe physical processes proceed in iterative steps, then the mathematics that dominate the universe are of an iteration nature.

Define any general iteration step can be expressed in the form

$$\mathbf{I}_{n+1} = \mathbf{I}_n + {}^{I}\boldsymbol{\Delta}_n \qquad \textbf{I-01}$$

where **I** is the iteration process property , n = iteration step, **Δ** is the iteration change of the iteration property. eg ${}^{I}\boldsymbol{\Delta}_n$ is the change of the **I** iteration property of the nth iteration step and **I-01** expresses that the iteration property **I** of the n+1 iteration step is the addition of the same iteration property **I** on the n iteration step plus the change of the **I** iteration property of the nth iteration step.

Iteration of the motion of an entity E.

Location displacement :

Consider that an entity has a designated property of a location **x** in a physical space of dimension D.

$\mathbf{x}_n$ is the location in a physical space of the entity at an iterative step n in that physical space, and $\mathbf{x}_{n+1}$ is s the location in a physical space of the entity at the next iterative step n+1 in that physical space. Then using I-01

$$\mathbf{x}_{n+1} = \mathbf{x}_n + {}^{x}\boldsymbol{\Delta}_n \qquad \textbf{I-02}$$

where ${}^{x}\boldsymbol{\Delta}_n$ is a displacement or change of the entity location taking place in the n iteration step.

I-02 represents an iteration step for the displacement or motion of an entity in nth iteration step.

Velocity:

The physics the definition of the displacement or change of location of an entity is the velocity **v** of an entity. Ie

$$\mathbf{v}_n = \mathbf{x}_n - \mathbf{x}_{n-1} \qquad \textbf{I-03a}$$

$$= \mathbf{x}_{n-1} - {}^{x}\boldsymbol{\Delta}_{n-1} - \mathbf{x}_{n-1}$$

$$= {}^{x}\boldsymbol{\Delta}_{n-1} \qquad \textbf{I-03}$$

or

$$\mathbf{v}_{n+1} = {}^{x}\boldsymbol{\Delta}_n \qquad \textbf{I-04}$$

Consider expressing a change in velocity for an iterative n+1 step as

$$\mathbf{v}_{n+1} = \mathbf{v}_n + {}^{v}\boldsymbol{\Delta}_n \qquad \textbf{I-05}$$

where ${}^{v}\boldsymbol{\Delta}_n$ is a displacement or change of the entity velocity taking place in the n iteration step.

Using **I-03** obtain

$$\mathbf{v}_{n+1} = {}^{x}\boldsymbol{\Delta}_{n-1} + {}^{v}\boldsymbol{\Delta}_n \qquad \textbf{I-06}$$

By definition ${}^{v}\boldsymbol{\Delta}_n$ is a change in velocity for the nth iteration step, and as such implies

$${}^{v}\boldsymbol{\Delta}_n = \mathbf{v}_{n+1} - \mathbf{v}_n = (\mathbf{x}_{n+1} - \mathbf{x}_n) - (\mathbf{x}_n - \mathbf{x}_{n-1})$$

$$= \mathbf{x}_{n+1} - 2\mathbf{x}_n - \mathbf{x}_{n-1}$$

using **I-02** for $\mathbf{x}_{n+1}$ gives

$$= \mathbf{x}_n + {}^{x}\boldsymbol{\Delta}_n - 2\mathbf{x}_n - \mathbf{x}_{n-1}$$

$$= {}^{x}\boldsymbol{\Delta}_n - \mathbf{x}_n - \mathbf{x}_{n-1} \qquad \textbf{I-07}$$

Substituting **I-7** into **I-06** gives

$$\mathbf{v}_{n+1} = {}^{x}\boldsymbol{\Delta}_{n-1} + {}^{x}\boldsymbol{\Delta}_n - \mathbf{x}_n + \mathbf{x}_{n-1}$$

$$= ({}^{x}\boldsymbol{\Delta}_n - \mathbf{x}_n) + (\mathbf{x}_{n-1} + {}^{x}\boldsymbol{\Delta}_{n-1})$$

utilising **I-02** $\mathbf{x}_n = \mathbf{x}_{n-1} + {}^{x}\boldsymbol{\Delta}_{n-1}$

$$= ({}^{x}\boldsymbol{\Delta}_n - \mathbf{x}_n) + \mathbf{x}_n$$

$$= {}^{x}\boldsymbol{\Delta}_n$$

which confirms **I-04**

Thus displacement of an entity location expressed by **I-02** can be rewritten if not already obvious as

$$\mathbf{x_{n+1} = x_n + v_{n+1}} \qquad \textbf{I-08}$$

What has been demonstrated here are the iterative equivalence of the classical equations of motion for velocity where the time interval is reduced to one single iterative step. The displacement or change of location of an entity in an iterative step is the velocity of that entity in that step, and is also the gradient or derivative of the motion of an entity in that iterative step.

Per iteration step

Change of location = velocity = gradient = derivative of motion of entity.

Acceleration:

The classical definition of acceleration of an entity is defined as the change in velocity of that entity over a time period. For a single period of an iteration, that time period is one and acceleration **a** for the n+1 iteration can be defined as

$$\mathbf{a_{n+1} = v_{n+1} - v_n} \qquad \textbf{I-09}$$

using **I-05**

$$\mathbf{= v_n + {}^v\Delta_n - v_n}$$

$$\mathbf{= {}^v\Delta_n}$$

and using **I-07**

$$\mathbf{= {}^x\Delta_n - x_n - x_{n-1}} \qquad \textbf{I-10}$$

$$\mathbf{= {}^x\Delta_n - (x_{n-1} + {}^x\Delta_{n-1}) - x_{n-1}}$$

$$\mathbf{= {}^x\Delta_n - {}^x\Delta_{n-1}} \qquad \textbf{I-11}$$

$$\mathbf{= v_n - v_{n-1}} \qquad \textbf{I-12}$$

Which by **I-11** gives and expression for the acceleration of an entity of the n+1 iteration as a function of the displacement of that entity in the n and n-1 iteration. The displacements that are the gradients or derivatives of the n and n-1 iteration.

Jerk (Jolt) :

Definition of change of acceleration of an entity is called the jerk or jolt (**j**) of that entity. For a single period of an iteration, that time period is one and the jerk **j** for the n+1 iteration can be defined as

$$\mathbf{j_{n+1} = a_n + {}^a\Delta_n} \qquad \textbf{I-13}$$

The definition of a change in acceleration of an entity defined as the change in acceleration of that entity over a time period is designated as the word jerk or jolt **j**. For a single period of an iteration, that time period is one and jerk **j** for the n+1 iteration can be defined as

$$\mathbf{j_{n+1} = a_{n+1} - a_n} \qquad \textbf{I-14}$$

The acceleration **a** for the n+1 iteration can be expressed as

$$\mathbf{a_{n+1} = a_n + {}^a\Delta_n} \qquad \textbf{I-15}$$

where $\mathbf{a_n}$ is the acceleration of the entity in the nth iteration step, and ${}^a\Delta_n$ is a change of the entity acceleration taking place in the nth iteration step.

Reasons for considering and exploring changes in acceleration of an entity is simply that all forces of electromagnetism and gravity have changes in acceleration of entities due to these forces that is dependent upon their distance from each each other.

Substituting $\mathbf{a_{n+1}}$ from **I-15** into **I-14** gives

$$\mathbf{j_{n+1} = a_n + {}^a\Delta_n - a_n}$$

$$\mathbf{= {}^a\Delta_n} \qquad \textbf{I-15}$$

The differential of the jerk or jolt **j** of the nth iteration.

Breaking $\mathbf{{}^a\Delta_n}$ down

$$\mathbf{{}^a\Delta_n = a_{n+1} - a_n}$$

by using **I-11** becomes

$$=({}^{x}\boldsymbol{\Delta}_{n} - {}^{x}\boldsymbol{\Delta}_{n-1}) - ({}^{x}\boldsymbol{\Delta}_{n-1} - {}^{x}\boldsymbol{\Delta}_{n-2})$$

$$= {}^{x}\boldsymbol{\Delta}_{n} - 2\,{}^{x}\boldsymbol{\Delta}_{n-1} + {}^{x}\boldsymbol{\Delta}_{n-2} \qquad \textbf{I-16}$$

$$= \mathbf{v}_{n} - 2\mathbf{v}_{n-1} + \mathbf{v}_{n-2} \qquad \textbf{I-17}$$

Which by **I-16** gives and expression for the jerk or jolt of an entity of the n+1 iteration as a function of the displacement of that entity in the n, n-1 and n-2 iteration. The displacements that are the gradients or derivatives of the n, n-1 and n-2 iterations.

Total displacement or distance:

Generally, the total displacement or distance **S** travelled by an entity over n iteration steps is the summation of all of the entity displacements for each i iteration step, ${}^{x}\boldsymbol{\Delta}_{i}$. ie

$$\mathbf{S} = \sum_{i=0}^{i=n-1} s_i = \sum_{i=0}^{i=n-1} {}^{x}\Delta_i \qquad \textbf{I-18}$$

Velocity:

${}^{x}\boldsymbol{\Delta}_{i}$ can be considered by utilising **I-04** as a velocity of an entity within the ith iteration and thus **I-18** can also be written as

$$S = \sum_{i=0}^{i=n-1} v_i \qquad \textbf{I-19}$$

where $\mathbf{v}_i$ is the displacement or velocity of the entity within the ith iteration.

Consider that ${}^{x}\boldsymbol{\Delta}_{i} = \mathbf{v}_i$ are of a constant value or velocity for all iterations i. ie ${}^{x}\boldsymbol{\Delta}$ or v. Then have

$$\mathbf{S} = \sum_{i=0}^{i=n-1} {}^{x}\Delta = (n-1)\,{}^{x}\boldsymbol{\Delta} \qquad \textbf{I-20}$$

which gives in classical physics the total number of iteration steps (n-1) as time and ${}^{x}\boldsymbol{\Delta}$ is a constant velocity, which gives

$$\mathbf{S} = \mathbf{v}\Delta t$$

Acceleration:

A changing entity displacement ${}^{x}\boldsymbol{\Delta}_{i}$ or velocity $\mathbf{v}_i$ for each iteration is defined as an acceleration over two iterations as given by **I-09** to **I-12**. However, the total displacement or distance **S** travelled by an entity undergoing acceleration is still defined by **I-18** or **I-19**. Acceleration is defined by classical physics as a change in velocity per interval of time. For an iteration, acceleration can be thought of as also a change in velocity per iteration. However, acceleration, like velocity, at its most fundamental level, is still an expression of change of an entity's location per iteration, only that the rate of change of an entity's location per iteration is not constant from the nth iteration to the n+1 iteration.

Consider that in the nth iteration, an entity location is displaced by ${}^{x}\boldsymbol{\Delta}_{n}$ from its initial location $\mathbf{x}_n$ to give a location $\mathbf{x}_{n+1}$ in the n+1 iteration. Consider that in the n+1 iteration, an entity location is displaced by ${}^{x}\boldsymbol{\Delta}_{n+1}$ from its initial location $\mathbf{x}_{n+1}$, to give a location x_{n+2} in the n+2 iteration. ie

$$\mathbf{x}_{n+1} = \mathbf{x}_{n} + {}^{x}\boldsymbol{\Delta}_{n} \qquad \textbf{I-21a}$$

$$\mathbf{x}_{n+2} = \mathbf{x}_{n+1} + {}^{x}\boldsymbol{\Delta}_{n+1} \qquad \textbf{I-21b}$$

The displacement or distance from the nth iteration to the n+2 iteration is the sum of **I-21a** and **I-21b**. Since it is only a displacement and no initial location is required for calculating a distance, $\mathbf{x}_n$ can be considered as equalling to zero.

$$\mathbf{s}_{n+1} = \mathbf{x}_{n+1} + \mathbf{x}_{n+2}$$

$$= (\mathbf{x}_{n} + {}^{x}\boldsymbol{\Delta}_{n}) + (\mathbf{x}_{n+1} + {}^{x}\boldsymbol{\Delta}_{n+1})$$

$$= 2(\mathbf{x}_{n} + {}^{x}\boldsymbol{\Delta}_{n}) + {}^{x}\boldsymbol{\Delta}_{n+1} \qquad \textbf{I-21c}$$

Since it is only a displacement and no initial location is required for calculating a distance, $\mathbf{x}_n$ can be considered as equalling to zero, =>

$$\mathbf{s}_{n+1} = 2({}^{x}\boldsymbol{\Delta}_{n}) + {}^{x}\boldsymbol{\Delta}_{n+1} \qquad \textbf{I-21}$$

By extending this sequence to the $\mathbf{s}_{n+2}$ iteration, it becomes apparent that the displacement of an entity undergoing acceleration is a feedback loop, where the total displacement up to any iteration step requires the processes of all of the previous iteration steps to be performed. Summing all individual iteration displacements of **I-21** will give a total displacement S or distance of an entity undergoing acceleration.

$$\mathbf{S} = \sum_{i=0}^{i=n-1} \boldsymbol{s_i} = \sum_{i=0}^{i=n-1} \left(x_i + {}^{x}\Delta_i\right) \quad \textbf{I-22a}$$

Consider that $\mathbf{x_i} = \mathbf{s_{i-1}}$ for i > 0

If it is considered that $\mathbf{s_{i-1}}$ is a displacement of the previous iteration, and that the definition of a displacement of an entity for one time period is a velocity, then $\mathbf{s_{i-1}}$ can be defined as an initial velocity of an entity for the ith iteration period and is a displacement of the entity that is to occur in the current iteration if no change to this iteration initial velocity takes place. ie $\mathbf{v_i} = \mathbf{s_{i-1}}$

If such a change in displacement in the ith iteration were to take place compared to the i-1 iteration, then ${}^{x}\boldsymbol{\Delta}_i$ is a change in the displacement of an entity in the ith iteration above that of its initial velocity given for that ith iteration by $\mathbf{s_{i-1}}$, which is also a change in velocity of the current iteration. ie $\mathbf{s_{i-1}} + {}^{x}\boldsymbol{\Delta}_i$ is an expression of the acceleration $\mathbf{a_i}$ of the entity in the ith iteration step in terms of displacement of the entity. ie $\mathbf{v_i} = \mathbf{s_{i-1}} + {}^{x}\boldsymbol{\Delta}_i = \mathbf{s_i}$. To avoid confusion with earlier declarations, ${}^{x}\boldsymbol{\Delta}_i$ needs to be replaced with ${}^{s}\boldsymbol{\Delta}_i$ to indicate that this is a change in the displacement of an entity in the ith iteration compared to the previous i-1 iteration. Thus have

$$\mathbf{S} = \mathbf{s_0} + \sum_{i=1}^{i=n-1} \boldsymbol{s_i} = \mathbf{x_0} + {}^{x}\boldsymbol{\Delta}_0 + \sum_{i=1}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^{s}\Delta_i\right) \quad \textbf{I-22}$$

and considering that it is displacement only that is being summed, $\mathbf{x_0} = 0$ =>

$$\mathbf{S} = {}^{x}\boldsymbol{\Delta}_0 + \sum_{i=1}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^{s}\Delta_i\right) \qquad \textbf{I-23}$$

Acceleration of an entity can thus be stated as a change in rate of displacements between one iteration and the next. ie acceleration $\mathbf{a_i} = \mathbf{s_i} - \mathbf{s_{i-1}} = {}^{s}\boldsymbol{\Delta}_i$.

Expanding **I-23** a recursive pattern emerges as

$$\mathbf{S} = {}^{x}\boldsymbol{\Delta}_0 + ({}^{x}\boldsymbol{\Delta}_0 + {}^{s}\boldsymbol{\Delta}_1) + \sum_{i=2}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^{s}\Delta_i\right)$$

$$= {}^{x}\boldsymbol{\Delta}_0 + ({}^{x}\boldsymbol{\Delta}_0 + {}^{s}\boldsymbol{\Delta}_1) + ({}^{x}\boldsymbol{\Delta}_1 + {}^{s}\boldsymbol{\Delta}_2) + \sum_{i=3}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^{s}\Delta_i\right)$$

$$= {}^{x}\boldsymbol{\Delta}_0 + ({}^{x}\boldsymbol{\Delta}_0 + {}^{s}\boldsymbol{\Delta}_1) + (({}^{x}\boldsymbol{\Delta}_0 + {}^{s}\boldsymbol{\Delta}_1) + {}^{s}\boldsymbol{\Delta}_2) + ({}^{x}\boldsymbol{\Delta}_2 + {}^{s}\boldsymbol{\Delta}_3) + \sum_{i=4}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^{s}\Delta_i\right)$$

$$= {}^{x}\boldsymbol{\Delta}_0 + ({}^{x}\boldsymbol{\Delta}_0 + {}^{s}\boldsymbol{\Delta}_1) + (({}^{x}\boldsymbol{\Delta}_0 + {}^{s}\boldsymbol{\Delta}_1) + {}^{s}\boldsymbol{\Delta}_2) + ((({}^{x}\boldsymbol{\Delta}_0 + {}^{s}\boldsymbol{\Delta}_1) + {}^{s}\boldsymbol{\Delta}_2) + {}^{s}\boldsymbol{\Delta}_3) + ({}^{x}\boldsymbol{\Delta}_3 + {}^{s}\boldsymbol{\Delta}_4) + \sum_{i=5}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^{s}\Delta_i\right)$$

$$= n({}^{x}\boldsymbol{\Delta}_0) + (n-1)({}^{s}\boldsymbol{\Delta}_1) + (n-2)({}^{s}\boldsymbol{\Delta}_2) + (n-3)({}^{s}\boldsymbol{\Delta}_3) + (n-4)({}^{s}\boldsymbol{\Delta}_4) + \ldots\ldots + (1)({}^{s}\boldsymbol{\Delta}_{n-1})$$

$$= n({}^{x}\boldsymbol{\Delta}_0) + \sum_{i=1}^{i=n-1} (n-i)\,{}^{s}\Delta_i \qquad \textbf{I-24}$$

which can be interpreted as equivalent for iteration of equal time duration to

$$\mathbf{S} = n\mathbf{v_0} + \sum_{i=1}^{i=n-1} (n-i)\,{}^{s}\Delta_i = \mathbf{v_0}t + \sum_{i=1}^{i=n-1} (n-i)\,{}^{s}\Delta_i \qquad \textbf{I-25}$$

if have constant acceleration $\mathbf{a} = {}^{s}\boldsymbol{\Delta} = {}^{s}\boldsymbol{\Delta}_i$ for all i iterations, then **I-24** becomes

$$\mathbf{S} = n({}^{x}\boldsymbol{\Delta}_0) + {}^{s}\Delta \sum_{i=1}^{i=n-1} i$$

and $\sum_{i=1}^{i=n} i = \frac{n(n+1)}{2}$ or $\sum_{i=1}^{i=n-1} i = \frac{n^2-n}{2}$ =>

$$\mathbf{S} = n({}^{x}\boldsymbol{\Delta}_0) + {}^{s}\Delta \frac{n^2-n}{2} \qquad \textbf{I-26}$$

Consider that ${}^{x}\boldsymbol{\Delta}_0$ is the initial velocity of the entity, ${}^{s}\boldsymbol{\Delta}$ is the constant acceleration, and n is the time of duration then **I-26** can be expressed as

$$\mathbf{S} = \mathbf{v_0 t} + \frac{1}{2}\boldsymbol{a}\left(\boldsymbol{t}^2 - \boldsymbol{t}\right) \qquad \textbf{I-27}$$

for very large number of iterations, $n^2-n \approx n^2 \Rightarrow t^2-t \approx t^2$ confirming that this iteration approach agrees with the classical equation of motion of an entity undergoing constant acceleration that has been derived using integral calculus

Thus to calculate the displacement or distance an entity traverses in n iterations, only the initial displacement or velocity in the first iteration is needed to be known, and the acceleration or changed displacements between each iteration, then the summation equation **I-24** can be applied.

I-24 applies to all situations of motion, including entities experiencing jerk (jolt) changing acceleration, constant acceleration, or constant velocity. The location of an entity in any iteration **i** is an expression of the initial location $\mathbf{x_0}$ of that entity plus the displacement given by **I-22**, and the end location after completing n iterations is

$$\mathbf{x_n} = \mathbf{x_0} + \mathbf{s_n} = \mathbf{x_0} + n({}^{x}\mathbf{\Delta_0}) + {}^{s}\Delta \sum_{i=1}^{i=n-1} i \qquad \textbf{I-28}$$

which is equivalent to the classical equation of motion

$$\mathbf{x_n} = \mathbf{x_0} + \mathbf{v_0 t} + \frac{1}{2}\boldsymbol{a}\boldsymbol{t}^2 \qquad \textbf{I-29}$$

for very large number, n, of iterations.

Jerk or Jolt:

All classical defined forces of electromagnetism and gravity have the force defied as

Force = mass x acceleration

or in algebraic form

$$F = ma$$

the force, and hence acceleration experienced on an entity for electromagnetism and gravity changes in proportion to the inverse of the square of the distance, r, an entity *E* of mass m is to another entity that it is interacting with, and which is attributed to as the source of the interacting force. For electromagnetism

$$F = ma = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$$

and for gravity

$$F = ma = G\frac{mM}{r^2}$$

=>

$$a = G\frac{M}{r^2}$$

Thus as r changes, so does the acceleration experienced by entity *E*, and this change in acceleration is defined and named as the jerk or jolt **j** that entity *E* experiences as its distance from the entity it is interacting with changes.

Consider that in any n+1 iteration, the jolt, **j**, experienced by an entity is defined as the change in acceleration of the n+1 iteration compared to the acceleration of the n iteration as given by **I-14**, which can be also written as **I-15**.

The displacement or distance **s** travelled for an acceleration in the n+1 iteration is defined by

$$\mathbf{s_{n+1}} = \mathbf{s_n} + {}^{s}\mathbf{\Delta_n} \qquad \textbf{I-30}$$

if ${}^{s}\mathbf{\Delta_{n-1}} \neq {}^{s}\mathbf{\Delta_n}$ then entity *E* undergoes a jerk or jolt between iteration n and n+1 and that jolt $\mathbf{j_n}$ for the n iteration is

$$\mathbf{j_n} = \mathbf{a_n} - \mathbf{a_{n-1}} = {}^{s}\mathbf{\Delta_n} - {}^{s}\mathbf{\Delta_{n-1}} = {}^{a}\mathbf{\Delta_n} \qquad \textbf{I-31}$$

=>

$${}^{s}\mathbf{\Delta_n} = \mathbf{j_n} + {}^{s}\mathbf{\Delta_{n-1}} = {}^{a}\mathbf{\Delta_n} + {}^{s}\mathbf{\Delta_{n-1}} \qquad \textbf{I-32}$$

Substituting **I-34** into **I-30** obtain the displacement or distance traversed by an entity in the nth iteration is

$$\mathbf{s}_{n+1} = \mathbf{s}_n + {}^s\Delta_{n-1} + \mathbf{j}_n = \mathbf{s}_n + {}^s\Delta_{n-1} + {}^a\Delta_n \quad \textbf{I-33}$$

Thus the total displacement or distance **S** traversed by an entity over n iterations is.

$$\mathbf{S} = \mathbf{s}_0 + \sum_{i=1}^{i=n-1} \boldsymbol{s_i} = {}^x\Delta_0 + \sum_{i=1}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^s\Delta_{i-1} + {}^a\Delta_i\right) \qquad \textbf{I-34}$$

where $\mathbf{s}_{i-1} = \sum_{j=1}^{j=i-1} \boldsymbol{s_j}$ **I-34** is an altered expression of **I-23**.

Expanding **I-34** is similar to expanding **I-23**.

$$\mathbf{S} = {}^x\Delta_0 + ({}^x\Delta_0 + {}^s\Delta_0 + {}^a\Delta_1) + \sum_{i=2}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^s\Delta_{i-1} + {}^a\Delta_i\right)$$

$$= {}^x\Delta_0 + ({}^x\Delta_0 + {}^s\Delta_0 + {}^a\Delta_1) + (\mathbf{s}_1 + {}^s\Delta_1 + {}^a\Delta_2) + \sum_{i=3}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^s\Delta_{i-1} + {}^a\Delta_i\right)$$

$$= {}^x\Delta_0 + ({}^x\Delta_0 + {}^s\Delta_0 + {}^a\Delta_1) + (({}^x\Delta_0 + {}^s\Delta_0 + {}^a\Delta_1) + {}^s\Delta_1 + {}^a\Delta_2) + (\mathbf{s}_2 + {}^s\Delta_2 + {}^a\Delta_3) + \sum_{i=3}^{i=n-1} \left(\boldsymbol{s_{i-1}} + {}^s\Delta_{i-1} + {}^a\Delta_i\right)$$

$$= n({}^x\Delta_0) + (n-1)({}^s\Delta_0 + {}^a\Delta_1) + (n-2)({}^s\Delta_1 + {}^a\Delta_2) + (n-3)({}^s\Delta_2 + {}^a\Delta_3) + (n-4)({}^s\Delta_3 + {}^a\Delta_4) + \ldots\ldots + (1)({}^s\Delta_{n-2} + {}^a\Delta_{n-1})$$

Any ${}^s\Delta_n = ({}^s\Delta_{n-1} + {}^a\Delta_n)$ from **I-33** =>

$$\mathbf{S} = n({}^x\Delta_0) + (n-1)({}^s\Delta_0 + {}^a\Delta_1) + (n-2)({}^s\Delta_0 + {}^a\Delta_1 + {}^a\Delta_2) + (n-3)({}^s\Delta_0 + {}^a\Delta_1 + {}^a\Delta_2 + {}^a\Delta_3) + (n-4)({}^s\Delta_0 + {}^a\Delta_1 + {}^a\Delta_2 + {}^a\Delta_3 + {}^a\Delta_4) + \ldots\ldots + (1)({}^s\Delta_0 + {}^a\Delta_1 + {}^a\Delta_2 + {}^a\Delta_3 + \ldots. + {}^a\Delta_{n-1}) \qquad \textbf{I-35}$$

$$= n({}^x\Delta_0) + \sum_{i=j}^{i=n-1} {}^s\Delta_0 i + \sum_{i=1}^{i=n-1} (n-i)\,{}^a\Delta_1 + \sum_{i=2}^{i=n-1} (n-i)\,{}^a\Delta_2 + ..+ \sum_{i=n-1}^{i=n-1} (n-i)\,{}^a\Delta_{n-1}$$

$$= n({}^x\Delta_0) + \sum_{i=j}^{i=n-1} {}^s\Delta_0 i + \sum_{i=1}^{i=n-1} \sum_{k=i}^{k=n-1} (n-k)\,{}^a\Delta_i \qquad \textbf{I-36}$$

of which the first two terms is equivalent to **I-26**, and thus **I-36** becomes

$$\mathbf{S} = n({}^x\Delta_0) + {}^s\Delta_0 \frac{n^2-n}{2} + \sum_{i=1}^{i=n-1} \sum_{k=i}^{k=n-1} (n-k)\,{}^a\Delta_i \qquad \textbf{I-37}$$

of which, as for the distance traversed under a constant acceleration is equivalent to

$$\mathbf{S} = \mathbf{v_0 t} + \frac{1}{2}\boldsymbol{a_0}\left(\boldsymbol{t^2 - t}\right) + \sum_{i=1}^{i=n-1} \sum_{k=i}^{k=n-1} (n-k)\,{}^a\Delta_i \qquad \textbf{I-38}$$

where ${}^a\Delta_i$ is the jerk or jolt value for the i iteration of a total of n iteration intervals.

Consider that the jerk or jolt is constant for all n iterations. ie ${}^a\Delta_i = {}^a\Delta$ for all I, then all ${}^a\Delta_i$ in **I-35** = ${}^a\Delta$ => have k ${}^a\Delta$ for each n-k summation of **I-38**. ie

$$\mathbf{S} = n({}^x\Delta_0) + (n-1)({}^s\Delta_0 + {}^a\Delta) + (n-2)({}^s\Delta_0 + {}^a\Delta + {}^a\Delta) + (n-3)({}^s\Delta_0 + {}^a\Delta + {}^a\Delta + {}^a\Delta) + (n-4)({}^s\Delta_0 + {}^a\Delta + {}^a\Delta + {}^a\Delta + {}^a\Delta) + \ldots + (1)({}^s\Delta_0 + {}^a\Delta + {}^a\Delta + {}^a\Delta + \ldots. + {}^a\Delta_{n-1})$$

or

$$\mathbf{S} = n({}^x\Delta_0) + {}^s\Delta_0 \frac{n^2-n}{2} + {}^a\Delta \sum_{i=1}^{i=n-1} (n-i)\,i \qquad \textbf{I-39}$$

$$= n({}^x\Delta_0) + {}^s\Delta_0 \frac{n^2-n}{2} + {}^a\Delta \sum_{i=1}^{i=n-1} ni - i^2 \qquad \textbf{I-40}$$

and using summation relationships $\sum_{i=1}^{i=N} i = \frac{N(N+1)}{2}$ and $\sum_{i=1}^{i=N} i^2 = \frac{N(N+1)(2N+1)}{6}$ with N = n-1, obtain

$$\mathbf{S} = n({}^x\Delta_0) + {}^s\Delta_0 \frac{n^2-n}{2} + {}^a\Delta \left[\frac{n(n^2-n)}{2} - \frac{((n-1)n(2(n-1)+1))}{6}\right]$$

$$= n({}^x\boldsymbol{\Delta}_0) + {}^s\Delta_0 \frac{n^2-n}{2} + {}^a\Delta\left[\frac{(n^3-n^2)}{2} - \frac{(2n^3-3n^2+n)}{6}\right]$$

$$= n({}^x\boldsymbol{\Delta}_0) + {}^s\Delta_0 \frac{n^2-n}{2} + {}^a\Delta\left[\frac{(3n^3-3n^2)}{6} - \frac{(2n^3-3n^2+n)}{6}\right]$$

$$= n({}^x\boldsymbol{\Delta}_0) + {}^s\Delta_0 \frac{n^2-n}{2} + {}^a\Delta\left[\frac{n^3-n}{6}\right] \qquad \textbf{I-41}$$

Consider that ${}^x\boldsymbol{\Delta}_0$ is the initial velocity and ${}^s\boldsymbol{\Delta}_0$ is the initial acceleration at the first iteration period of the entity, and ${}^a\boldsymbol{\Delta}$ is the constant change of acceleration or jerk, (jolt) **j**, and n is the time of duration, then **I-41** can be expressed as

$$\mathbf{S} = \mathbf{v_0 t} + \frac{1}{2}\boldsymbol{a_0}(\boldsymbol{t}^2-\boldsymbol{t}) + \boldsymbol{j}\left[\frac{\boldsymbol{t}^3-\boldsymbol{t}}{6}\right] \qquad \textbf{I-42}$$

For very large number of iterations, $n^2-n \approx n^2 \Rightarrow t^2-t \approx t^2$ and $n^3-n \approx n^3 \Rightarrow t^3-t \approx t^3$, confirming that this iteration approach agrees with the classical equation of motion of an entity undergoing a constant jerk that has been derived using integral calculus.

I-42 applies to all situations of motion, including entities experiencing jerk (jolt) changing acceleration, constant acceleration, or constant velocity. The location of an entity in any iteration **i** is an expression of the initial location $\mathbf{x_0}$ of that entity plus the displacement given by **I-22**, and the end location after completing n iterations is

$$\mathbf{x_n} = \mathbf{x_0} + \mathbf{s_n} = \mathbf{x_0} + n({}^x\boldsymbol{\Delta}_0) + \sum_{i=j}^{i=n-1} {}^s\Delta_0 i + \sum_{i=1}^{i=n-1}\sum_{k=i}^{k=n-1} (n-k)\,{}^a\Delta_i \qquad \textbf{I-43}$$

which is equivalent to the classical equation of motion

$$\mathbf{x_n} = \mathbf{x_0} + \mathbf{v_0 t} + \frac{1}{2}\boldsymbol{a}_0^2 + \frac{1}{6}\boldsymbol{j}\boldsymbol{t}^3 \qquad \textbf{I-44}$$

for very large number, n, of iterations and constant change of acceleration, jerk **j**.

Conclusion:

In this section, it has been demonstrated that an iteration approach to defining the motion of an entity is viable, simple and agrees with the traditional approach of integral calculus. Acceleration and jerk have been demonstrated as a feedback process that is an accumulation of all previous changes of motion, or at least for a single iteration, is a feed back response from the most recent and previous iteration process.

In **I-27** and **I-42**, the inclusion of the t^2-t and t^3-t is an indication that within a single iteration on its own, no acceleration or jerk can be defined or discovered, as t^2-t and t^3-t = 0 for a single period of iteration. This also gives an indication that if the universe operates as a series of iterative events, as the physics model approaches that of the physical process single iteration events, or at small time scales or distances that are of a scale of these events, iteration relationships like **I-27** and **I-42** become more prevalent. It is also an indication that the use of calculus that relies on a continuous number field is prone to increasing error and is no longer valid to use.

Through derivation of acceleration and jerk, the displacement or distance traversed relationships of **I-25** and **I-41** indicate that acceleration and jerk is a parameter of the history of an entity over more than one iteration. Velocity can be determined in a single iteration by a measurement of the difference of displacement of an entity within an iteration. Acceleration, and jerk requires a known history of entity displacement, and each has have within them, the accumulated history of of these displacements, as **I-24** and **I-38** shows.

In **I-24** it can be argued that the acceleration $\mathbf{a_i}$ in any iteration i, is a measurement of the difference of the ith iteration velocity or displacement from an initial i=0 iteration velocity or displacement. Similarly,In **I-38** it can be argued that the jolt $\mathbf{j_i}$ in any iteration i, is a measurement of the difference of the ith iteration acceleration from an initial i=0 iteration acceleration.

If a unified theory of the universe is to be found for all the interpreted observed forces at play, each force is in essence a process of acceleration and jerk. As demonstrated here, acceleration and jerk processes are feedback processes that can be expressed as a summation of iteration steps prior to the iteration step being measured, and as such, a unifying theory of forces will involve a physical process of feedback, which in turn can be a sign of self interaction from one period of iteration to the next.

An iteration model perspective:

Any model of the processes of the universe based upon an iteration step method would not have acceleration or jerk being a part of that individual iteration step as acceleration and jerk is a function of more than one iteration step, and is also a derived interpretation from the mathematics of calculus. Acceleration and jerk are thus observed emergent resultant behaviour of the physical process that increases an entities motion of displacement within that one iteration step in which it occurs.

It is often stated that Einstein's field equation of general relativity being, without explaining it is

$$R_{\mu\nu}-\frac{1}{2}g_{\mu\nu}+\Lambda g_{\mu\nu}=\frac{8\pi G}{c^4}T_{\mu\nu} \qquad \textbf{I-45}$$

where the left side of the equation states the geometry of space that is determined or generated by the right side (the mass-energy of entities), and which then in turn reacts to this geometry to cause motion of the mass-energy entities, that in turn, then generate a new geometry of space to react to, and so on. This may just be such an iterative physical feedback process in which the motion from one iterative step to the next is determined by the conditions at any iterative step, and not by an equation derived from a set of observation measurements, such as Newton's equation of gravitation.

Einstein's field equation may be a mathematical expression of the underlying physical process of gravity that is taking place. This field equation gives a mathematical model that gravity is of a geometric nature and that entities that have a property of mass react from one moment to the next based upon the interpreted resultant geometry of space that the masses either modify, or create through interaction. In an iteration model, the action of an entity in any iteration is an action to the geometry surrounding the local vicinity of the entity at that iteration step. The geometry surrounding the local vicinity of the entity at that iteration step is determined by an accumulation of past iteration steps that has created that geometry of space.

With this in mind, what is interpreted as acceleration or jolt is a function of the geometry of space in the vicinity of the entity, not an action at a distance given by an equation such as Newtons law of gravity. That geometry of space at that location in space in that iteration step is a function of all past iteration steps of interaction, including that of a model of space interacting with itself.

An analogy would be dropping a pebble into a pond of calm water with a ball floating some distance from where the pebble was dropped. The ball does not react to the pebble, but to the disturbances of the water that the pebble has created by its interaction with the water. Being some distance from the location where the pebble was dropped, it takes some time, or number of iterations or physical processes to occur before any of those disturbances reach the ball, and for the ball to react to those disturbances. This is how an iteration model of the physical processes of the universe would be constructed. This is also a proposal of the underlying physics governing the universe and all its processes, and that such an iteration model is more relevant and accurate to give a greater understanding and knowledge of its inner workings than by the search for equations. Equations that rely on a mathematical approach that may break down at the most fundamental level at the heart of all physical processes and observation.

Iteration Model

Iteration step time :

It the universe processes progress as a series of iteration steps, then there should be a set minimum time duration that a single step can be performed in. Such a time step can be speculated by the one constant of the universe that does not vary in any reference frame, and is measured and proved to constant in all. That being the velocity of light.

Light, or photon, is prevalent in all physical processes of atomic interaction, and it has been theorised and proven that gravitational waves propagate at the velocity of light. Consider that the process of the propagation of light is an iterative process within an iteration step model of the universe. To find this iteration duration as a time value, consider that an iteration process is a change of physical state of a photon. Considering that the photon is an interpretation as a wave, this change of physical state is that from the assumed photon wave peak to the assumed photon wave trough, or from the trough to the peak . That is, half a wavelength λ.

Consider that the velocity of light c is defined as $c = \dfrac{\frac{\lambda}{2}}{\Delta t} = \dfrac{\lambda}{2\Delta t}$ **IM-01**

where Δt is the duration that light takes to traverse one half of a wavelength, or one iteration.

The relationship **IM-01** indicates that as the wavelength of a photon changes, the period of iteration changes in proportion. Many visible light wavelengths are in the range of $4\text{x}10^{-7}$ to $7\text{x}10^{-7}$ meters, which translates into possible iteration periods of Δt being in the range of $0.6666\ \text{x}10^{-15}$ to $1.2666\ \text{x}10^{-15}$ seconds.

In physics, there is a relationship between the energy E of a photon, and the measured interpreted wavelength λ, given by the equation

$$E = hf = h\frac{c}{\lambda} \qquad \textbf{IM-02}$$

where c = velocity of light, h = Plank's constant.

if it is assumed that the iteration for a photon to change its energy state is of a period from peak to trough of a single photon, then **IM02** becomes.

$$2E = \frac{\frac{hc}{\lambda}}{2} = \frac{2hc}{\lambda}$$

the velocity of light can be considered as the displacement or distance between peak and trough of a photon wave, c = λ/2 =>

$$2E = \frac{2h\frac{\lambda}{2\Delta t}}{\lambda} = \frac{h}{\Delta t} \qquad \textbf{IM-03}$$

=>

$$E\Delta t = \frac{h}{2} \qquad \textbf{IM-04}$$

and substituting the values for h, obtain.

$$E\Delta t = (6.62607015 \text{ x } 10^{-34})/2$$
$$= 3.31302557 \text{ x } 10^{-34} \text{ Joule-seconds}$$
$$\approx 3.313 \text{ x } 10^{-34} \text{ Joule-seconds}$$

Thus the iteration period of any photon from its wave peak to trough is ≈ $3.313 \text{ x } 10^{-34}$ Joule-seconds, which also by the speculation given here, is the iteration period in seconds for all photon processes.

This implies that from **IM-04**, that the duration of iteration process is in proportion to the inverse of the energy of the interaction, and that the process of energy changing the physical state occurs in one iteration.

Consider that an electron has a charge energy of ≈ $1.602 \text{ x } 10^{-19}$ Joules, then an interaction involving an electron may have an iteration period of ≈ $3.313 \text{ x } 10^{-34} / 1.602 \text{ x } 10^{-19}$ seconds ≈ $2.068 \text{ x } 10^{-15}$ seconds.

This agrees with the possible iteration periods for the propagation of visible light as given by **IM-01**.

The possible iteration periods given by **IM-01** and **IM-04** are not of the shortest duration as there exists higher energy and shorter photon wavelengths that may be more applicable to nuclear processes. What the shortest iteration duration is, and which other processes of the universe are derived or built from needs to found.

This could possibly be the theoretical plank time of ≈ 5.3912×10^{-44} seconds, but it is not advocated just yet.

Consider Einstein's famous energy equation $E = mc^2$.

For an electron-positron pair production process,

$$E \approx 2 \times (9.1093837 \times 10^{-31}) \times (2.99792458 \times 10^{8})^2$$

$$\approx 1.63742 \times 10^{-13} \text{ joules}$$

=> Δt for electron-positron pair production process is ≈ $1.63742 \times 10^{-13} / 3.31302557 \times 10^{-34} \approx 4.94235 \times 10^{-20}$ seconds, if the process of proton-positron pair production is true for **IM-04**.

Such time periods are not possible to measure with the current technology and physics time clocks that use radioactive decay processes. Thus the iteration period being less than the current time clocks is not possible to be measured, only speculated and theorised.