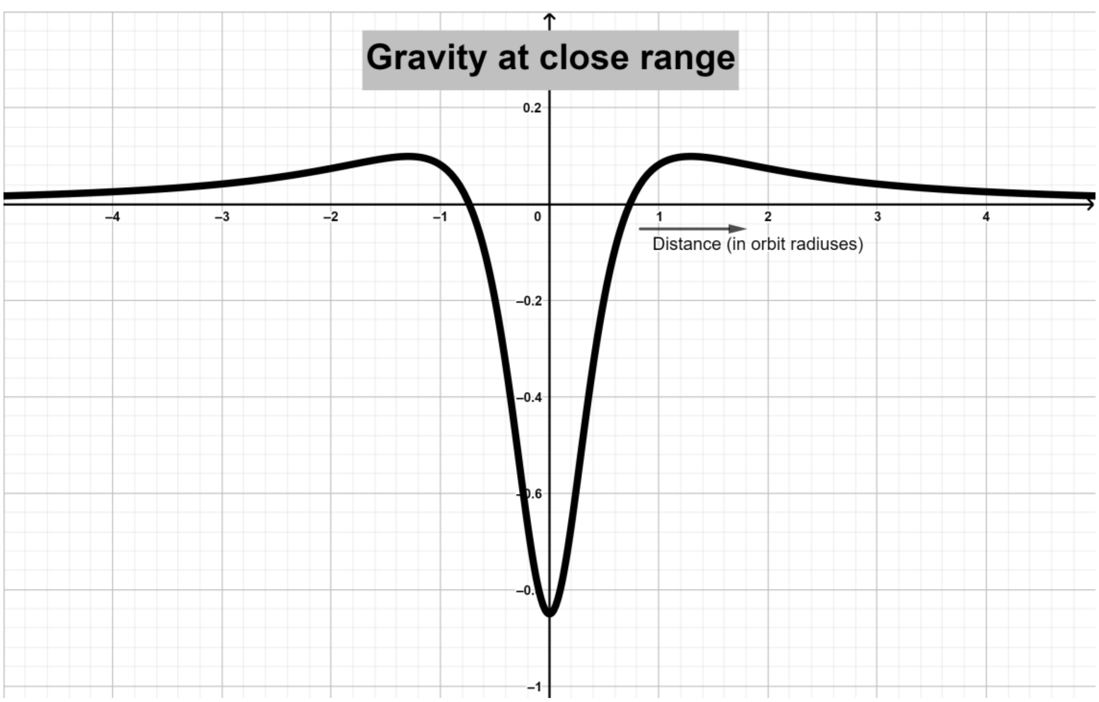
Leveraging Boltzmann, Einstein, Planck:

How Reverse Engineering a Streamlined System of Units of Measurement Led to Gravity

Hans van Kessel, Oktober 2022

(Version 2)



Summary

To conceptualize the contents herein, the reader should be familiar with…

Boltzmann's equation $S = k_B . \ln(w)$
Einstein's equation $E = m.c^2$
Planck's equation $E = h.\nu$

These equations shaped a mainstream runway for modern physics. But that runway was constructed on an existing field. A shared system of *Units of Measurement* thereby frames each equation. This system can only be adapted with utmost care since any potential error would have fundamental consequences. Utmost care costs time. For example, only in 1983 was it agreed to replace *distance* measurements by *time* measurements (multiplied with the velocity of light). This update, based on Einstein's theory of relativity (some 28 years after his passing) as well as significant experimental data, streamlined the system of *Units of Measurement*, and thereby multiple theories and equations.

This is how it works in general. We verify our equations and theories through experiments. Thereby, all results are based on the current system of *Units of Measurement*. Only very occasionally does this lead to a streamlining of the system. The latter then typically is a by-product, and not an intention. There are few exceptions.

But what would happen should we reverse that by basing a system of *Units of Measurement* on a presumed validity of our equations? The forthcoming system would inherently confirm the validity of the equations that it is based upon. In its concept this would therefore deliver a 'belly watching' system rather than objective science.

Yet at some point in time, one may have developed enough trust in some equations to dare follow this reverse approach. In a way, this is comparable to using computers for designing a next generation of computers.

In this manuscript we will trust the validity of the above three equations. As we will see, this not only leads to an extremely streamlined system of *Units of Measurement*, but also reveals how bits and pieces fall together. Gravity finds its place.

I adapted my language to first year students in physics. But don't let that mislead you. My objective is to reach all. Hoping to inspire.

Notes to version 2.

Based on feedback the document has been streamlined and further clarified. In the previous version I used - besides a Cartesian frame of reference- a frame that is based on a photon's path. Although it describes the same physics, it deviates from other more commonly used perspectives. For example, when Einstein referred to the curving of space (as an effect of gravity), that curving is not equal to the curving of a photon's path. In the curved space he was referring to, photons 'spin out'. However, within a frame that is based on the photon's path, photons inherently do not spin out. This led to discussion on **www.vixra.com** and a disconnect in understanding. Therefore, an additional paragraph discusses 'frames of reference'. Einstein's 'relativistic factor 2' is explained (a photon's path curves twice the curving of space, as caused by gravity, hence this factor). Finally, some layout improvements make this manuscript more readable.

About (the making of) this Manuscript

As a physics student at the Technical University Delft (Netherlands), my prime goal was to jump through the hula hoop of graduation. I did. But I also found that physics deserved better. As one of my professor's stated, 'physicists are the richest people': they can travel (in mind) through the entire universe in a way that couldn't be afforded by the combined wealth of all the billionaires in the world. I wanted such travel too. At that time, I decided that once, in a then far away utopian future, I would depart.

And about 30 years later that moment arrived. Departing rather empty bagged from a scientific point of view, I thereby found myself in a surprisingly large wild west arena of 'lunatics' (my words): generally lone wolves, like myself. But when I derived 'Planck's units' without intention and without initially even realizing this; I gained confidence. Apparently, despite limited luggage, I didn't derail from mainstream physics. I found intriguing results in my efforts by standing on the shoulders of Boltzmann, Einstein, and Planck.

Over the past 10 years I published some results while 'enroute' on **www.vixra.org**, a lightning rod for lunatic thoughts, but also a place for needles in the haystack. This manuscript describes my entire travel so far. It embeds some of the previous publications. Pieces thereof turned out to fit in a beautiful way, shaping a summit from which I could see bottoms of deeper valleys. *Information* and *Gravity* found a place.

It is time to share this.

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(1) Streamlining Units of Measurement (UoM's)

A scientific description of the natural world requires a system for Units of Measurement (*UoM's*). In general, physics uses the International System (*S.I.*), from the French 'Système International d'unités'.

As we will discuss, the *S.I.* is neither *normalized* nor *absolute*. Though this will not lead to false results, it blurs some fundamentals of physics and leads to mathematical complications that, at the bottom line, are man-made.

To avoid this, we begin our effort by developing a streamlined system of *UoM's*. To silence the alarm that might go off here, this chapter introduces no more than two physical properties and their respective *UoM's* (Chapter 4 introduces a third).

a) Normalized

Consider Einstein's equation:

$$E = m.c^2$$

'*E*' is the *energy* in *Joule*
'*c*' is the light *velocity* in vacuum in *m/s*
'*m*' is the *mass* in *kg*

The parameter '*m*' has a story behind it. We will address that later. For now, we will evaluate the equation as is.

The equation can be rewritten as:

$$c^2 = {}^{E}/_{m}$$

The *UoM's* at each side of the equation must be of equal dimension. Consequently:

$$\left(c_{({}^{m}/_{s})}\right)^2 \equiv \frac{J}{kg}$$

Light *velocity* '*c*' (in vacuum) then equals the square root of the above:

$$c \equiv \sqrt{{}^{J}/_{kg}}$$

However, as shown in the above equation, in the *S.I.* light *velocity* '*c*' is expressed in *m/s*:

c = 299,792,458 ${}^{m}/_{s}$

It is of constant value, equal to all. Therefore:

$$\sqrt{{}^{J}/_{kg}} \equiv 299{,}792{,}458\ {}^{m}/_{s}$$

If then, for example, one would redefine the *UoM* for *mass* (the *kg*), the above relationship shows that this cannot be done without impacting at least one of the other *UoM's*.

Einstein's equation $E = m.c^2$ thus reveals relationships between *UoM's*. Relationships between *UoM's* must be 'universally equal', i.e.: equal to all regardless the observer's local circumstances. This ensures that physical equations such as Einstein's $E = m.c^2$ will hold true for all.

Ideally all *UoM's* are independent relative to each other. They are *normalized*. If not, a full understanding of what we are measuring becomes more complex.

> *Consider that the x, y, and z coordinates in a spatial Cartesian frame of reference are normalized. For a given point in space, a change in the 'yardstick' for the x-coordinate would act upon the numerical value of that x-coordinate, but it would not act upon the numerical values of the y or z coordinates.*

(1) In a *normalized* set of *UoM's*, a change to any *UoM* (or '*standard*' thereof) has no impact on any of the other parameters.

This feature ensures an exclusive relationship between what we are measuring per parameter and what we are monitoring.

b) Absolute

A second complexity in the *S.I.* is the definition of '*standards*' (or '*yardsticks*') per *UoM*. Ideally these are universally equal. If so, then when comparing data, we can be sure that everyone used the same frame of reference.

(2) The universal equality of its *standards* qualifies a system of *UoM's* as *absolute*.

This second ideal is ensured when all *UoM's* are based on 'universal natural constants'. As the name implies, these have equal value to anyone, anywhere, regardless of circumstances (relative, or not). The acid test for a yardstick to be *absolute* is that, regardless of relative circumstances, instructions can be remotely provided to reproduce it. A phone call could do it.

Apart from universal natural constants, within our system of *UoM's* we will allow mathematical constants like π, *e* and the *bit*, as well as mathematical operations such as multiplication or taking the square root.

(3) Mathematical rules/procedures are presumed to be universally valid.

(4) Mathematical constants (such as '*π*', '*e*' and the '*bit*') are presumed to be universally equal.

c) History

Historical efforts to streamline *UoM's* have been incorrectly referred to as normalization. The reality is that these efforts searched for a set of absolute yardsticks for existing *UoM's*. Mutual dependencies were not fully evaluated simply because some of the dependencies (as discussed in Einstein's equation, for example) were not yet known. We will therefore redo it.

Our objective is to come up with a system of *UoM's* that is both *normalized* and *absolute*.

d) Avoiding a Pitfall

Thereby, from a mathematical perspective, setting several universal natural constants equal to the dimensionless '1' is a valid option. It reduces the number of dimensions and thereby reduces the number of relationships between *UoM's*. Stoney followed this approach. Planck did something likewise about 30 years later, eliminating natural constants from physical equations.

Paul S. Wesson wrote:

"Mathematically it is an acceptable trick which saves labour. Physically it represents a loss of information and can lead to confusion."
(see reference [4])

In the extreme case, all universal natural constants could be set to dimensionless '1'. This would then leave us with a completely dimensionless physics. Such physics could not possibly describe anything at all and therefore couldn't be wrong either.

In fact, the differentiating *UoM's* between the various universal natural constants define the true variety in physical properties. Given this, we must insist that each universal natural constant indeed has a unique and thus distinguishing *UoM*. Should two of these constants share a *UoM*, one of them would be superfluous in that it can be expressed as a fraction of the other and therefore it would not distinguish itself from a physical perspective.

To avoid any potential loss of physical information, we will restrict ourselves to no more than one universal natural constant set to dimensionless '1'. The respective *UoM's* will thus positively distinguish all universal natural constants relative to each other. In other words: we will allow ourselves no more than 'one single candy' from the collection in the box.

There is no guarantee that the list of universal natural constants, as currently provided by science, is complete. We will have to live with that. Obviously, the relevancy of any newly discovered universal natural constant can hardly be overestimated. This is illustrated by the impact of Einstein's finding that light *velocity* '*c*' is universally equal.

e) Introducing Crenel Physics

For clarity, we will refer to our intended streamlined system of *UoM's* as *Crenel Physics (CP)* as opposed to *Metric Physics* (based on the *S.I.*).

f) Content, Appearances and Packages

As said, Einstein found that light *velocity* '*c*' is universally equal. Therefore, Einstein's equation $E = m.c^2$ describes a universal (non-relativistic) relationship between *mass* '*m*' and *energy* '*E*'. It does not matter where you are within our universe or how fast you are traveling: if you hold a *mass* of 1 *kg* of matter in your hands, to you that *mass* represents a fixed amount (equal to c^2) of *energy* in *Joule*. Consequently, you can express the amount in your hands in *kg* or in *Joule* alike. This universal exchangeability is a decisive argument for both properties to share a common basis. That shared basis we will refer to as *Content*. All physical objects embed *Content* which per Einstein can be expressed in the *mass UoM* as well as in the *energy UoM*.

Consequently, we can do with one (and no more than one) measure or yardstick or *UoM* for *Content*. Within the *Crenel Physics* model, we will refer to it as a '*Package*':

(5) The physical property *Content* will be expressed in *Packages* ('*P*').

In doing so we still recognize that *mass* and *energy* indeed exist as two different physical concepts, but these will be viewed as two different *Appearances* of the physical property *Content*.

g) *Dimensions versus Appearances*

In *Metric Physics* the afore mentioned *mass* and *energy* are defined as *dimensions* to be expressed in *kg* and *J* respectively.

When a physical equation is verified, the verification for 'dimensional integrity' is one of the acid tests. For example, the *Joule* is equal to the force of 1 *Newton* acting through -a *distance* of- 1 *meter* (*J* = *N.m*). Due to such overlaps in *UoM's* within the *S.I.*, there is an extensive pallet of equalities between various combinations of various dimensions. Together these shape the tools used for 'dimensional analyses'.

To better differentiate between *Crenel Physics* and *Metric Physics* we will use the term '*Appearance*' rather than '*Dimension*'. The term *Appearance* rightfully suggests that by swapping between various *Appearances* of *Content* one is still looking at the same physical property. This will hold even though such swapping will typically require a completely different kind of sensor to monitor the *Appearance*.

Thereby, based on the conservation principles:

(6) A swap between *Appearances* of *Content* does not result in a change of the numerical value in *Packages*.

In the next chapter we will demonstrate that this indeed holds true within the *Crenel Physics* model, whereas it does not apply when swapping between *S.I.* dimensions ($\mathrm{e.g.}\, 1\, kilogram\ \neq 1\, Joule$). This differentiating feature justifies the introduction of *Appearances*.

The introduction of the physical property *Content,* being represented by the *Appearances mass* and *energy* (other *Appearances* of *Content* will follow), embeds Einstein's '*Principle of Equivalence*' into the *Crenel Physics* model.

This principle is the basis for the afore mentioned story behind the meaning of parameter 'm' in Einstein's equation $E = m.c^2$.

h) *The 'Principle of Equivalence'*

To Einstein this principle was no more than an assumption. Nevertheless, it is at the basis of the *Theory of Relativity*. By accepting the validity of Einstein's equation $E = m.c^2$ (and we do!) we thereby implicitly accepted this principle.

The symbol 'm' in *Metric Physics* (and in Einstein's equation) is potentially misleading in that it suggests that the total *mass* of two objects m_1 and m_2 add up to m_1+m_2. Typically, it doesn't. This is addressed by the 'principle of equivalence'.

In many cases the various impacts on 'm' will be extremely small. However, in -for example- iron atoms, these are relevant and clearly measurable. The mass of an iron atom is about 1% less than the sum of masses of its constituents (protons, neutrons, and electrons).

In *Crenel Physics* we abandon the usage of *mass* 'm' in Einstein's equation and remodel this to *Content*. Thereby, we will express *energy* (gravitational, kinetic, electrostatic, potential, thermal, etc.) in *Packages*, as we will express *mass* in *Packages*. And -as said- we will introduce additional *Appearances* of *Content*, all to be expressed in *Packages*.

When it comes to Newton's equations for *Gravity* and *Acceleration*:

(7) Per the *Crenel Physics* model, Newton's laws for *Gravity* and acceleration are not based on *mass* (gravitational or inert alike), but on *Content.*

Relevant experimental verification exists: iron atoms indeed behave as iron atoms (obeying Newton's laws) and not as *mass* aggregations of their individual constituents.

So let us continue our efforts with the above context in mind.

i) *Light Velocity c_{CP}*

By expressing both *mass* and *energy* in *Packages*, we implicitly normalized the conversion factor 'c^2' in Einstein's equation to dimensionless '1'. Within the *Crenel Physics* model light *velocity* '*c*' then is also equal to unity:

$\boldsymbol{c_{CP} \equiv 1}$	1.1

(Where 'CP' subscript indicates that a given property is the Crenel Physics version).

Any other *velocity* will be expressed as a fraction of light *velocity* 'c_{CP}'. Within *Crenel Physics*, *velocity* thus ranges from 0 to 1.

We thereby have eaten our 'single candy'. From here onwards no additional universal natural constant may or will be normalized through our upfront considerations. We will however find additional universal natural constants to also equal dimensionless '1'. This is a consequence of our choice to normalize '*c*'. Such will then be an un-blurring fact: such findings contribute to our insight into physics.

At this point our picking of '*c*' appears arbitrary since we started our considerations with Einstein's equation. In Chapter 8 we will argue that nature offers no alternative. The 'single candy' is indeed light *velocity* '*c*'.

j) Introducing the Crenel

Metric Physics expresses *velocity* in *m/s*. In *Crenel Physics*, to arrive at the now required dimensionless measure for *velocity*, the *UoM* for *distance* must be proportional to the *UoM* for *time*. For practical purposes we will use a ratio with the value 1, so that one *UoM* covers both. We will name it '*Crenel*' ('*C*').

Note that in Metric Physics, in essence this ratio has been set to 299,792,458 so that 1 second correspondents to 299,792,458 meters.

With both *distance* and *time* being expressed in *Crenel*, these are of equal physical property. We will name it '*Whereabouts*':

(8) The physical property *Whereabouts* will be expressed in *Crenel ('C')*

Memory aid: the name 'Crenel' is associated with crenels as found on top of castle walls. That shape has a pattern that can be associated with both distance as well as frequency (and thereby time).

Fig. 1.1: *Crenels* on Top of a Castle Wall

Within the *Crenel Physics* model, *distance* and *time* thus are two different *Appearances* of the physical property *Whereabouts*.

In doing so, a hypothetical change to the yardstick for *Whereabouts* (the *Crenel*) inherently has a proportionally equal impact to both the *distance* and *time Appearance*.

k) The 'Enhanced Principle of Equivalence'

We thereby 'de facto' enhanced Einstein's assumed '*Principle of Equivalence*' by revealing its forthcoming consequence to all *Appearances* that can be found within the *Whereabouts* arena. If changing, all these *Appearances* will change proportionally.

We will refer to this enhancement as the '*Enhanced Principle of Equivalence*'.

l) The Gravitational Constant G_{CP}

In *Metric Physics, Acceleration* is expressed in m/s^2. Therefore, in *Crenel Physics, Acceleration* is to be expressed in C/C^2. Simplified:

(9) *Acceleration* '*a*' is expressed in C^{-1}.

Based on Newton's laws, *force* is equal to *mass* times *acceleration* ($F = m.a$). In *Metric Physics, force F* is measured in $kg.m/s^2$. In *Crenel Physics* this converts to $P.C/C^2$ and thus:

(10) *Force* '*F*' is expressed in *P/C*.

From Newton's gravitational equation:

$$F = G.\frac{M_1.M_2}{d^2}$$

We extract *G*:

$$G = \frac{F.d^2}{M_1.M_2}$$

In the above we substitute the *Crenel Physics UoM's* for '*F*', '*d*' and '*M*':

$$G = \frac{\frac{P}{C}.C^2}{P.P} = {}^{C}/_{P}$$

Thus, we find the value of the gravitational constant within the *Crenel Physics* model:

$G_{CP} \equiv 1\ \frac{C}{P}$	1.2

Note that within our model the gravitational constant G_{CP} is found to equal the reciprocal (or 'multiplicative inverse') of the *UoM* for *force* (*P/C*).

m) Planck's Constant h_{CP}

From Planck's equation…

$E = h.v$

…we extract *h*:

$h = E/v$

In *Crenel Physics*, *energy* '*E*' is expressed in *Packages*.
In *Metric Physics*, *frequency* '*v*' is expressed in *seconds*$^{-1}$. The counterpart for *seconds*$^{-1}$ is *Crenel*$^{-1}$.

Substituting…

$$h = \frac{P}{C^{-1}}$$

…we find the value of Planck's universal natural constant '*h*' within the *Crenel Physics* model:

$$\boldsymbol{h_{CP} \equiv 1\, C.P} \qquad (1.3)$$

n) Planck Units

With three universal natural constants c_{CP}, G_{CP} and h_{CP} now defined, let's explore three forthcoming equations:

For light *velocity c*:

$$\boldsymbol{1\,(dimensionless) = c(m.s^{-1})} \qquad (1.4)$$

For Planck's constant *h*:

$$\boldsymbol{1\, P.C = h(N.m.s)} \qquad (1.5)$$

For the gravitational constant *G*:

$$\boldsymbol{1\, {}^{C}/_{P} = G(N.m^2.kg^{-2})} \qquad (1.6)$$

The left sides in each of these three equations express the universal natural constants (c_{CP}, h_{CP} and G_{CP} respectively) in *Crenel Physics UoM's*, whereas the right sides express these in *Metric Physics UoM's*.

Using 3 preparation steps, we can extract *P* and *C*, and express these in *S.I.* units as follows:

Preparation step 1:

Equation (1.4) can be rewritten as: $1\,(s) = c\,(m)$.

In doing so we follow the aforementioned '*Enhanced Principle of Equivalence*'.

Preparation step 2:

In equation (1.5) the *time Appearance* ('*s*') in the *UoM* for '*h*' can therefore be replaced by *c meter.*

This results in:

$$\boldsymbol{1\, P.C = h.c(N.m^2)} \qquad (1.7)$$

Preparation step 3:

Per Einstein's $E = m.c^2$, 1 *kg* is equivalent to c^2 *Joule* or c^2 *(N.m)*.
In equation (1.6) the kg^{-2} in the *UoM* can therefore be replaced by c^{-4} $(N^{-2}.m^{-2})$:

$$\boldsymbol{1\, {}^{C}/_{P} = G.c^{-4}(N.m^2.N^{-2}.m^{-2})}$$

or:

$$\boldsymbol{1\, {}^{C}/_{P} = G.c^{-4}(N^{-1})} \qquad (1.8)$$

With these 3 preparation steps completed we can divide equation (1.7) by equation (1.8):

$$P^2 = \frac{h.c^5}{G}(N^2.m^2) = \frac{h.c^5}{G}(Joule^2)$$

Or (by taking the square root):

$$\boldsymbol{1\, Package = \sqrt{\frac{h.c^5}{G}}\,(Joules)} \qquad (1.9)$$

=4.9033x10^{9} *J*

From here onwards some other conversion factors can be derived:

Because 1 *Joule* equals c^{-2} *kg*:

$$\mathbf{1\ Package} = \sqrt{\frac{\mathbf{h.c}}{\mathbf{G}}}\ (\mathbf{kilograms}) \quad (1.10)$$

=5.4557x10^{-8} *kg*

Based on Planck's $E = h.\upsilon$, equation (1.9) can likewise be converted to *frequency* (in *seconds*$^{-1}$):

$$1\ Package = \sqrt{\frac{h.c^5}{G}} \times \frac{1}{h}\ (s^{-1}) = \sqrt{\frac{c^5}{h.G}}\ (s^{-1})$$

Or:

$$\mathbf{1\ Package} = \sqrt{\frac{\mathbf{c^5}}{\mathbf{h.G}}}\ (\mathbf{Hertz}) \quad (1.11)$$

=7.4001x10^{42} *Hz*

Note: as we will see in Chapter 4, Planck's equation -and thereby equation (1.11)- only applies to Photons.

Equation (1.11) delivers *frequency* as the third *Appearance* (alongside *mass* and *energy)* in the *Content* arena.

The step from the *Content* arena to the *Whereabouts* arena is found by multiplying equation (1.7) with equation (1.8):

$$C^2 = \frac{h.G}{c^3}\ (meter^2)$$

or:

$$\mathbf{1\ Crenel} = \sqrt{\frac{\mathbf{h.G}}{\mathbf{c^3}}}\ (\mathbf{meter}) \quad (1.12)$$

=4.0512x10^{-35}*m*

And because one *meter* corresponds to c^{-1} *seconds*:

$$\mathbf{Crenel} = \sqrt{\frac{\mathbf{h.G}}{\mathbf{c^5}}}\ (\mathbf{seconds}) \quad (1.13)$$

=1.3513x10^{-43}*s*

For further enhancement we will preliminarily define a scale for temperature. Chapter 4 discusses *temperature* in more detail, thereby finding that -conditionally- it is a fourth *Appearance* of *Content*.

In *Metric Physics* the *UoM* for *temperature* is defined as follows:

$$1\ UoM\ for\ Temperature = \frac{UoM\ for\ Energy}{k_B}$$

There are various versions of k_B (Boltzmann's constant) which will also be addressed in Chapter 4. To ensure dimensional integrity in the above equation, in *Metric Physics* the *J/K* version for k_B must be used. Since *energy* is expressed in *Joule*, the above equation then results in the *Kelvin* ('*K*') as the *UoM* for *temperature*.

In the above definition for a *temperature UoM*, equation (1.9) can be substituted as the *UoM* for *energy* (in *Joule*). These substitutions deliver the conversion factor between the *UoM* for *temperature* within the *Crenel Physics* model (T_{CP}) to the *Kelvin*:

$$\mathbf{1^0 T_{CP}} = \sqrt{\frac{\mathbf{h.c^5}}{\mathbf{G.(k_{B(J/K)})^2}}}\ (\mathbf{Kelvin}) \quad (1.14)$$

=3.5515x10^{32} *K*

Equations (1.9) through (1.14) show resemblance with the well-known 'Planck units', albeit that the above equations hold Planck's constant '*h*', whereas the 'Planck units' hold the *reduced* Planck constant '*h/2.π*' (symbol: '$\hbar$'). Had for Planck's equation $E = h.\upsilon$ the alternate and equally valid version $E = \hbar\omega$ been used in the above, the result would have been fully consistent with Planck's *UoM's*.

(11) *Crenel Physics* is *frequency* based, whereas Planck units in *Metric Physics* are based on *angular frequency*.

In Chapter 4 we will argue our choice.

The above demonstrates how our limited system of physical properties -*Content* in *Packages* and *Whereabouts* in *Crenel*- nevertheless delivers a set of yardsticks for *mass*, *energy*, *frequency*, and *temperature* in the *Content* arena, and *time*, *distance* in the *Whereabouts* arena. All are exclusively based on universal natural constants and mathematical procedures, and thus these yardsticks are *absolute*.

Note: Chapter 3 will address why the two physical properties 'Content' and 'Whereabouts' are 'normalized'.

With c being normalized to the dimensionless '1', within the *Crenel Physics* model we can simplify the listed *UoM's*:

$\mathbf{1\ P} = \sqrt{\frac{\boldsymbol{h_{cp}}}{\boldsymbol{G_{cp}}}}$	$(\boldsymbol{Energy})$	1.15
$\mathbf{1\ P} = \sqrt{\frac{\boldsymbol{h_{cp}}}{\boldsymbol{G_{cp}}}}$	$(\boldsymbol{Mass})$	1.16
$\mathbf{1\ P} = \sqrt{\frac{\mathbf{1}}{\boldsymbol{h_{cp}}.\boldsymbol{G_{cp}}}}$	$(\boldsymbol{Frequency})$	1.17
$\mathbf{1\ C} = \sqrt{\boldsymbol{h_{cp}}.\boldsymbol{G_{cp}}}$	$(\boldsymbol{Distance})$	1.18
$\mathbf{1\ C} = \sqrt{\boldsymbol{h_{cp}}.\boldsymbol{G_{cp}}}$	$(\boldsymbol{Time})$	1.19

These yardsticks generally apply to any system in which light *velocity* 'c' has been normalized to the dimensionless '1'.

(2) Testing the Streamlining

Prior to enhancing the *Crenel Physics* model, let us test what we have thus far by exploring the four *Appearances* (*mass*, *energy*, *frequency*, and *temperature*) in which we can express *Content*.

a) Mass

The *mass* of an electron is found to equal 9.1094×10^{-31} *kg*.

Because one *mass UoM* in *Crenel Physics* equals 5.4557×10^{-8} *kg* (see equation (1.10)), an *electron* therefore contains…

$$\frac{9.1094\text{x}10^{-31} kg}{5.4557\text{x}10^{-8}\ kg} = 1.6697\text{x}10^{-23}\ Packages$$

…when measured in the *mass Appearance*.

b) Energy

Per Einstein's equation $E = m.c^2$, we find the electron to contain 8.1871×10^{-14} *J* of *energy*.

Because one *energy UoM* in *Crenel Physics* equals 4.9033×10^{9} *J* (see equation (1.9)), an electron therefore contains…

$$\frac{8.1871\text{x}14^{-14}\ J}{4.9033\text{x}10^{9}\ J} = 1.6697\text{x}10^{-23}\ Packages$$

…when measured in the *energy Appearance*.

c) Frequency

Per Planck's equation $E = h.\upsilon$, the *electron*'s *Content* can also be represented as a *frequency* of 1.2356×10^{20} *Hz*.

Because one *frequency UoM* in *Crenel Physics* equals 7.4001×10^{42} *Hz* (see equation (1.11)), an electron therefore contains…

$$\frac{1.2356\text{x}10^{20}\ Hz}{7.4001\text{x}10^{42}\ Hz} = 1.6697\text{x}10^{-23}\ Packages$$

…when measured in the *frequency Appearance*.

d) Temperature

Perhaps less obvious is the embedding of a *temperature UoM*.

By using the general equation…

$$T = \frac{h}{k_{B(J/K)}} \times \upsilon$$

…we can convert an electron's *frequency* into a *temperature*. This gives a value of 5.9299×10^{9} *K*.

Note: we will later explain the background of the above equation (Chapter 4, equation (4.20)).

Because one *temperature UoM* in *Crenel Physics* is equal to 3.5515×10^{32} *K* (see equation (1.14), an electron therefore contains…

$$\frac{5.9299\text{x}10^{9}\ \text{K}}{3.5515\text{x}10^{32}\ K} = 1.6697\text{x}10^{-23}\ Packages$$

…when measured in the *temperature Appearance*.

Thus, for each of these *Appearances* of *Content* we found *the electron's numerical* value:

$$1\ electron = 1.6697\text{x}10^{-23}\ Packages$$

Conclusion:

(12) Within the *Crenel Physics* model, we can freely swap between the various *Appearances* of *Content* without impacting the numerical value thereof.

Based on the afore mentioned '*enhanced principle of equivalence*' the same holds for all *Appearances* within the *Whereabouts* arena:

(13) Within the *Crenel Physics* model, we can freely swap between the various *Appearances* of *Whereabouts* without impacting the numerical value thereof.

(3) An Ultimate View on the Conservation Principle

Equation (1.17),

$$1\,P = \sqrt{\frac{1}{h_{cp}.G_{cp}}}\ (Frequency)$$

expresses the *Package* in the *frequency Appearance*, thus in *Crenel^{-1}*. It is based on universal natural constants only. The *Crenel Physics* model thus reveals a universal relationship between its two physical properties: *Content* and *Whereabouts* (Chapter 4 introduces a third physical property: *Information*).

a) Swapping between Content and Whereabouts

To explore the mechanism of swapping between *Content* and *Whereabouts*, we start with reviewing the sequential mathematical steps to convert *Content* into *Whereabouts*:

1. INVERT the conversion factor for *Content* per equation (1.15) or (1.16).
   This results in:
   $$\sqrt{\frac{G_{cp}}{h_{cp}}}$$
2. MULTIPLY WITH PLANCK'S CONSTANT 'h_{cp}':
   $$\sqrt{h_{cp}.G_{cp}}$$
   This result matches equations (1.18) and (1.19).

The exact same steps can be used to reconvert *Whereabouts* back into *Content*:

1. INVERT the conversion factor for *Whereabouts* per equation (1.18) or (1.19).
   This results in:
   $$\sqrt{\frac{1}{h_{cp}G_{cp}}}$$
2. MULTIPLY WITH PLANCK'S CONSTANT 'h_{CP}':
   $$\sqrt{\frac{h_{cp}}{G_{cp}}}$$
   This result matches equations (1.15) and (1.16).

The equality between the conversion and reconversion procedure is remarkable. The failsafe approach to reconvert to the original is to undo each conversion step in reverse order. In this case however, each of the following statements hold true:

- ✓ Applying the conversion procedure twice results in the original value, regardless of whether one starts with the *Package* or with the *Crenel*.
- ✓ Applying the conversion procedure twice has the same impact as a multiplication with dimensionless '1'.

From a mathematical perspective it is exclusively the 'multiplicative inverse' operation which has this feature.

Example: the 'multiplicative inverse' of 'x' equals '1/x'. And the 'multiplicative inverse' of '1/x' equals the original 'x' again. Furthermore, the product of some 'x' with its inverted value '1/x' always yields dimensionless '1'. This holds true regardless of the value (numeric or otherwise) of 'x', with of course, the exception of '0'.

We apply this mathematical insight to the above two equal conversion procedures. Mathematics says that:

(14) *Content* (in *Packages*) is equal to inverted *Whereabouts* (in *Crenel*)

And vice versa:

(15) *Whereabouts* (in *Crenel*) is equal to inverted *Content* (in *Packages*)

The conversion/reconversion procedure that we found does however consists of two steps rather than one single step. This does not contradict the above mathematical conclusion. To verify this, we take a closer look at the second step of the procedure.

Given the above mathematical perspective, that the *Package* and *Crenel* are found reciprocal, their product *C.P* must be equal to dimensionless '1'. This implies that per equation (1.3) Planck's constant:

$$h_{CP} = 1\,C.P \equiv 1$$

Within the *Crenel Physics* model, it mathematically therefore equals the dimensionless '1'. Thus, a multiplication with Planck's constant (step 2 of the procedure) has no mathematical impact on the outcome. It does however result in a physical property swap between *Crenel* and *Package*.

This gives a deeper insight into the conversion procedure**.** The first step (the inversion step) **is** the swap between *Crenel* and *Package.* The second step (i.e., multiplication with Planck's constant 'h_{CP}') only ensures that this swap is processed 'dimensionally'.

Note that we thereby referred to 'Content' and 'Whereabouts' as 'dimensions'. When compared to Metric Physics, these lay one level 'deeper'.

Should we therefore conclude that Planck's constant h_{CP} equals dimensionless '1'and thus is equal to light *velocity* 'c_{CP}'? Is Planck's constant over dimensioned when we say it is equal to *P.C* (instead of 1)?

There is a physical argument to not follow this mathematical logic. When we refer to the product '*P.C*', we refer to Planck's constant which is in fact the 'inner product' (also referred to as 'scalar product') '*P.C*' of two physical properties '*P*' and '*C*' respectively. This inner product '*P.C*' must equal 1. If such were not the case, the sequential applying of the conversion and reconversion procedures would not result in the original value. From a physical perspective, we would violate the conservation principle should the original result not materialize.

Our conclusion therefore is that within our model light *velocity* c_{CP} is equal to dimensionless '1', whereas Planck's constant h_{CP} represents the *inner product* (or *scalar product*) of the *Crenel* and the *Package*.

Recall Paul S. Wesson's statement (Chapter 1). Planck's constant is an example of a universal natural constant that indeed embeds 'physical information', even though mathematically it has a value equal to dimensionless '1'.

At this point we conclude:

(16) To 'dimensionally' complete an inversion of either the *Crenel* or the *Package*, we must multiply the outcome with Planck's constant h_{CP}.

b) The Conservation Principle's Bottom Line

By revealing that *Content* (in *Packages*) is equal to inverted *Whereabouts* (in *Crenel*) and vice versa, the *Crenel Physics* model demonstrates these properties to be *normalized*.

This finding also gives an ultimate view on the conservation principle, in that *Content* can be replaced by inverted *Whereabouts*, and vice versa.

The exchange rate can also be found by rewriting equation (1.2) $G_{CP}=1\ C/P$ as:

$$\boldsymbol{C = G_{CP} \times P} \qquad (3.1)$$

As we will see, this insight is at the root of explaining and quantifying the gravitational force.

(4) How Boltzmann Enhances Planck and Explains Heisenberg

Let's start by reviewing Boltzmann's theory.

In his equation:

$$S = k_B . ln\,(w) \tag{4.1}$$

S = *Entropy*
We will detail the meaning of *Entropy* later.

k_B = Boltzmann's universal natural constant

w = Number of states in which a system can be found, where the following thereby applies:

- ✓ ***w* is a *natural number* (also referred to as *counting number*).**
  Partial states, intermediate states, or a simultaneous mixture of states (as found in quantum physics) is not foreseen.
- ✓ $\boldsymbol{w > 0}$
  If at any moment we take a snapshot of a system, we will find it in one of its potential states. Thus, there is at least one state.
- ✓ **The number of states '*w*' in which a system can be found is equal to all observers and thus is not subject to the *Theory of Relativity*.**
  For example, to all the throw of a dice results in 6 possible states (1 through 6), thus to all '*w*'=6.
  We therefore classify '*w*' as a 'hardware' property. Per equation (4.1), *Entropy* '*S'* then also qualifies as a 'hardware' property.
- ✓ **Each potential state must have equal probability.**
  In many cases this holds true. Where not, the equation needs correction.

With '*w*' having potential values 1, 2, 3, 4, etc., the term $ln\,(w)$ in the equation has a 'non-negative real' numerical value, so that Boltzmann's constant k_B and *Entropy* '*S*' have equal sign and *UoM*.

a) Various Options for Boltzmann's Constant

In *Metric Physics*, Boltzmann's constant k_B (and thus *Entropy* '*S*') can be expressed in various *UoM's*, from microscopic such as *nat* and *bit* to macroscopic such as *Hz/K* and *J/K*, with values for these examples as follows:

$k_{B(nat)}$	=1	*nat*
$k_{B(bit)}$	=1.442695…	*bit*
$k_{B(Hz/K)}$	$=2.0836618… \times 10^{10}$	*Hz/K*
$k_{B(J/K)}$	$=1.3806488… \times 10^{-23}$	*J/K*

The *nat* is the **natural** *UoM* for *Information*. We will later address what qualifies it as 'natural'. Of note here is that Boltzmann's constant, when expressed in this *UoM*, has a numerical value 1 and thus:

(17) Boltzmann's constant k_B is equal to the natural *UoM* for *Information*.

The *bit* is an alternate *UoM* for *Information*:

(18) The *bit* is the amount of *Information* that informs us which one of two possible states (usually labelled '0' and '1') applies.

The *UoM's nat* and *bit* are mathematical entities (as is π, for example). The associated numerical values for k_B can therefore be shared between *Metric Physics* and *Crenel Physics*, as well as with any other system of *UoM's.* This portability makes Boltzmann's constant unique within the arena of universal natural constants.

With Boltzmann's constant in *nat* or *bit* being *UoM's* for *Information*, all alternatives are also *UoM's* thereof. The size of a computer's memory, for example, is commonly expressed in the number of *bits*. It may alternatively be expressed in *nat*, *Hz/K* or *J/K*.

From the above considerations we conclude:

(19) *Entropy* is an absolute universal measure for *Information Storage Capacity*.

There is a difference between *Information Storage Capacity* and *Information*, though the amount for both can be expressed in the same *UoM* (for example in *bits*). With *Information Storage Capacity* classified as a 'hardware' property, *Information* itself can be qualified as a 'software' property. For example, the *Information* which tells us in which state a system (such as a computer memory) resides may vary pending *time* (thus is 'soft'), whereas the number of potential states of that system is fixed (thus is 'hard'). Herein we are mindful to use these terms appropriately.

b) *Information*

Boltzmann's equation thus introduced *Information* into the *Crenel Physics* model. It impacts physics at its core, yet its role is often 'hidden behind a curtain'. For example, Boltzmann's constant is frequently presented as if it equals dimensionless '1' rather than 1 *nat*.

The following further illustrates this commonplace issue:

- ✓ We may, for example, specify the *mass* of an object to equal '15 *kg*'.
- ✓ This suggests that the *UoM* of this specification is the *kg* and no more than that.
- ✓ We may wrongly conclude that the '15' has no *UoM*. However, the here applied *UoM* is the *digit*.

Besides the already introduced *nat*, *bit*, *J/K*, and *Hz/K*, the *digit* is yet another *UoM* for *Information*.

(20) The *digit* is the amount of *Information* that informs us which one of 10 possible states (typically labelled 0 through 9) applies.

To unambiguously quantify the aforementioned '15 *kg*', we should specify it as '15 (*digital*) *kg*'.

But who would in daily practice? Yet such would be relevant to 'aliens' who might not have 10 fingers and are not familiar with the digit.

Unfortunately, the *S.I.* does not consistently use the *digit*. For example, one minute is 60 seconds (not 10), one hour is 60 minutes (not 10), one day is 24 hours (not 10), and one full turn is 360 degrees (not 10).

Where the *digit* is the commonly used default *UoM* in human communication, *binary* computers internally and exclusively use the *bit* as the *UoM* for *Information*.

By using the bit instead of the digit, on our ten fingers we can count to as much as $2^{10}=1024$, rather than to 10. When seen from this perspective, the digit is not the optimal choice.

Here we conclude that the '15' (in 15 *kg*) qualifies as *Information* because it is expressed in the *UoM digit*.

Information is a very broad concept. It has some general and distinguishing features that neither fit into the *Content* arena nor into the *Whereabouts* arena. A family picture for example, surely holds *Information*. It can be copied or multiplied without costs to the source. The conservation principles obviously do not apply to *Information*, whereas they do apply to the *Information Storage Capacity* (here: the paper that holds the picture). These distinguishing features justify that we define:

(21) *Information* is the third physical property within the *Crenel Physics* model.

For further analysis of its features, we will use the following definition (reference [5]):

(22) *Information* is a 'resolution of *uncertainty*'.

This definition has flaws. It may suggest that 'resolve' is equal to 'reduce'. Information may add to uncertainty.
The statement 'we found a bullet near the victim', for example, qualifies as Information. Yet it raises new questions and thereby adds to uncertainty.
In the following we will nevertheless stick to the above definition. We have the liberty to do so, with the disclaimer that this definition does not cover general purposes. It does cover ours.

We thereby differentiate between two types of *uncertainty*:

1. **'*State Uncertainty*'.**
   This type of *uncertainty* links to Boltzmann's equation (4.1) since the latter embeds the number of potential states '*w*'. Examples are:
   (1) The cat in the box is either dead, or alive (with a wink to 'Schrödinger's cat' experiment).
   Here, in Boltzmann's equation:
   w=2 (digital).
   (2) A dice may show 1, 2, 3, 4, 5, or 6.
   Here, in Boltzmann's equation:
   w=6 (digital).

2. **'*Quantitative Uncertainty*'.**
   This type of *uncertainty* is straightforward. For example, the *mass* of an object equals '*x*' *kg*. Parameter '*x*' expresses *uncertainty*: it may have any quantitative value.

The differences between both types of *uncertainty* demand different types of *Information*. We will use the following terminology:

- ✓ To resolve '*State Uncertainty*' we will need '*State Information*'.

- ✓ To resolve '*Quantitative Uncertainty*' we will need '*Quantitative Information*'.

Let's begin by exploring '*State Uncertainty*'. Recall that per Boltzmann's theory the number of possible states '*w*' is a *counting number* > 0.

In the case of a single state situation (*w*=1) there is no *uncertainty* to resolve when it comes to the actual state.

A 2-state situation (*w*=2) is the leanest option for creating '*State Uncertainty*'. Thereby, given its definition, the *bit* is the exact amount of *Information* that we would need to resolve it.

(23) The *bit* is the leanest amount, thus 'quantum' of *Information*, for resolving *state uncertainty*.

Some experimentation is justified to further draw back the curtain that typically hides *Information* and its features. Let's continue to focus on '*State Information*' and its potentials as well as limitations.

For such experiments the *binary* computer is a perfect tool as:

1. A *binary* computer's memory is an *Information Storage Capacity* constructed of hardware *bits*. Its size (as the size of individual data files therein) is universally equal.
2. *Binary* computers process *Information* exclusively in *bits*, thus in universally equal quanta of *State Information*.
3. *Binary* computers do nothing but execute sequences of pre-defined logical instructions between *bits* of *Information* or groups thereof. These processing instructions are universally equal, as is the sequence in which they are executed.

   The logical Shift Left, Shift Right, AND, OR, or NOR instructions, for example, are generally referred to as 'instructions at machine level'. More complex operations must first be compiled towards a set of such instructions before they can be executed.
   Although this set is limited and truly basic, the respective instructions can be executed fast. The pace is dictated by a high internal clock frequency. Therefore, the binary computer is rightfully nicknamed 'fast idiot'.

The above features ensure that:

(24) *Binary* computers produce universally equal results, regardless of relative circumstances.

Such cannot be taken for granted where alternative computing mechanisms are used.

Only the amount of time it will take to complete operations may appear different between observers. A computer's internal clock frequency will not appear universally equal pending relative circumstances and based on the Theory of Relativity.

The three features listed above ensure that *binary* computers exclusively handle '*State Information*'. Despite this, a very wide range of applications and a broad spectrum of *Information* can be handled. We will address a few concepts.

Each individual *state* of any *binary* memory section represents a unique series of *bits*, which in turn can be represented by a unique and exclusive *counting number* (here in the *binary* format).

To universally associate an equal and unique value to that sequence, we must demand an ordering sequence (or 'formatting') of the memory *bits* from 'most significant' to 'least significant'. For example, a 4-*bit binary* memory section may -after such ordering- contain the *Information*: 1011. Based on this 'format' we can assign a unique and universally equal *digital* representation: it would equal $(1x2^0)+(1x2^1)+(0x2^2)+(1x2^3) = 11$. Or in *hexadecimal* it would equal 'B'. Such ordering or 'formatting' allows us to count beyond the counting capabilities of the individual memory component, here the *bit*. But from a conceptual perspective there is no reason to demand such enhancement. In essence each individual *bit* is a *counter* by itself, and thus holds a *counting number*. *Counting numbers* therefore represent an overlap between *Quantitative Information* and *State Information*.

(25) '*State Information*' also supports '*counting numbers*', thus is equivalent to a special case of '*Quantitative Information*'.

The existence of this overlap ensures that both types of *Information* can share the same *UoM*. Therefore, in *Crenel Physics* terminology, we conclude that:

(26) '*State Information*' and '*Quantitative Information*' are two different *Appearances* of *Information*.

Binary computers can also handle *'real numbers'* and therefore the full range of '*Quantitative Information*'. However, unlike the counting number itself, a '*Quantitative Information'* embedding sign and/or a decimal point cannot be captured as is. Instead, these attributes are stored as '*formatted State Information*' based on some pre-defined 'format'. Various formats can be defined and agreed upon as nature has no preference.

A 'real number', for example, might be stored in a pre-defined (formatted) 32-bit memory section. Pending the selected format options within these 32 bits, the position of the decimal point may be thought fixed between two adjacent bit numbers. Alternately, it may be 'floating', that is its position is stored separately as a 'counting number'. Besides the '0' and '1' state, no third memory state is available for storing the decimal point character itself.
As is the case for the decimal point, the storage of the positive or negative sign of a numerical value must be based on some pre-defined format. Somewhere within the binary memory, one assigned bit must store it. Again, there is no mandatory rule for a location.
For as long as both readers as well as writers apply the same format (rule), things will work fine.

In addition, *binary* computers handle *Information* such as pictures, newspapers, colours, and plain text. Stored as formatted *binary* files, each file resides in one single state that uniquely represents the embedded *Information*. Thereafter, this binary *Information* can be processed and presented via a -format pending- universally equal procedure or 'algorithm'.

Dynamic *Information*, such as a movie, likewise qualifies as static state *Information*. A *binary* computer stores this in some chosen -yet inherently universally equal- format as a static *binary* file. Through some -format associated and thus also inherently universally equal- algorithm, its static state content is processed and presented as a sequence of static frames. The single relativistic aspect of such presentation is the *frequency* at which these frames follow each other, as 'seen' by remote observers.

c) Smooth Dynamics

Consistent with Boltzmann's theory, binary computers do not handle partial states, intermediate *states*, or a mixture of simultaneous *states* of *Information*. Where two sequential *states* differ, the difference must at least involve one single *bit* (i.e., one quantum of *state* resolving *Information*).

Despite not covering all features of 'mainstream' quantum physics, Boltzmann's theory nevertheless is a beginning: the differences in observed states are subject to quanta, equal to 1 *bit*.

This then implies that a *binary* computer can neither process nor present (but rather only simulate) a truly smooth unfolding of events.

Specifically, processing true smoothness in the unfolding of *time* would demand an infinite number of frames per time *UoM* as well as an infinite precision of events and their describing data, and thereby an infinite amount of '*Quantitative'* as well as *'State Information*'.

But while true smoothness cannot be realized within the constraints of a *binary* computer, this is not an argument to deny its existence in nature. Such deny may then -amongst others- imply that the existence of *Information* is to be based on the ability (or lack thereof) to store it; that -in order to exist- *Information* must physically reside somewhere.

As we will see, storage is not always required. It is sufficient to demand that:

(27) '*Information*' is 'available'.

The term '*available*' expresses that *Information* does not necessarily need to be stored.

Consider that the exact values of '1/3' and 'π' are universally 'available', yet their exact values cannot be stored within a finite memory. Nevertheless, in some cases, we can produce exact results and thus use the exact values without these being stored. For example, 1/3 of 6 apples equals exactly 2 apples. And sin(π) equals exactly 0.

Relevant examples of universally *available Information* are:

- ✓ Universal physical constants
- ✓ Mathematics
- ✓ Physical laws

The impossibility to store an infinite amount of *Information* thus can neither be a showstopper for producing exact results, nor for allowing true smoothness in the unfolding of nature as *time* proceeds. In demanding that any observation is a discrete 'state' observation, Boltzmann's theory **is** however a showstopper for allowing a truly smooth (and thus exact) *observation*. We will get back to this issue after some further elaboration and experimentation.

Consider that stored *'Information'* resides within (or is held by) a carrier if you will. Thereby, for example, a memory *bit* within a computer memory might be heavier when in state '1' relative to state '0' because, when in state '1', it happens to hold more electrons. But it might as well be the other way around. Therefore, in terms of *Crenel Physics*:

(28) there is no *Content* difference between the optional states of an *Information* carrier.

Note: the term 'Content' may lead to some confusion in relation to the term 'Information'. Within Crenel Physics 'Content' is measured in Packages whereas 'Information' is measured in bits (or nat, or J/K, to name a few).

Furthermore, relocating our family picture does not change the picture itself. That is, relocating the carrier (paper), does not change the *Information* (picture). Also, as already said, we can copy the picture (i.e.: the *Information*) without costs to its source.

To continue summarizing our findings:

(29) Conservation principles do not apply to *Information* ('software') whereas they may apply to *Information Storage Capacity* ('hardware').

(30) *Information* has neither *Content* nor inertia.

(31) *Whereabouts* does not impact *Information*.

Let us now focus on *Quantitative Information*.

When we previously specified '15 *kg*', mathematically this represents the inner product of '15' (*Quantitative Information* in the *digital format*) and '*kg*' (a *Content Appearance*).

Should we now change the *Quantitative Information* part of the specification, say from '15' to '16', this has no impact whatsoever on the *Content Appearance* '*kg*'.

In mathematical terms this demonstrates that:

(32) The physical property *Information* is independent from (or orthogonal to) both *Content* as well as *Whereabouts*.

Then how does the *Theory of Relativity* impact such specifications?

Per this theory, for example, an object will appear to gain *mass* as it gains *velocity* relative to the observer. In this case it is the *Content Appearance* that is gaining, not the *Quantitative Information*. This may raise eyebrows since it is not common practice to deal with the effects of relativity in this way. The common way would be that the original mass increased due to relativistic effects (velocity) from -for example- 15 *kg* to 16 *kg*. Therefore, let's go into some more detail here.

As said per *Crenel Physics*, when we specify that an object has a mass of '15 *kg*', the *Information* part '15' (*digit*) of this specification is universally equal. It is the *Content Appearance* '*kg*' that is subject to relativity and that gains relative to the observer.

In retrospect: for example equation (1.10)…

$1\,Package = \sqrt{\frac{h.c}{G}}\ (kilograms)$=5.4557x10^{-8} kg

…defines the absolute value of a *mass UoM* **locally**, to the observer.

While the *UoM* for the moving mass (in this example expressed in *kg*) appears heavier, any local *UoM* (here the *kg*) remains as is.
To then quantify a moving mass, a higher quantity of these local *kg* will be required to express the relativistic impact of *velocity*, i.e.: a higher mass of the moving object. The common practice of increasing the *quantity* wrongly suggests that the quantification part (the *Information* part) of the specification increased. In fact, it did not. It is the remote moving *kg* that appears heavier than the local *kg*.

The astronaut in his fastmoving spaceship can confirm this. He will not measure or experience a gain in his body mass (expressed in his local kg) due to his velocity relative to whatsoever. Per equation (1.10), his ***local*** *kg (being his mass UoM) remains unchanged because it is based on universal natural constants. The quantity thereof, that is, the Information part of the specification of his body mass, was found universally equal in the first place.*

> *Therefore, should his body mass be 75 kg while his spaceship stood still on Earth, he will locally still find his mass to be 75 kg after he is launched, and his acceleration has stopped.*

As for *Quantitative Information*, we previously found that *State Information* also is universally equal and thus not impacted by the *Theory of Relativity*.

We summarize that:

(33) *Information* is universally equal.

To further clarify this finding, let's perform two additional experiments that look at '*Quantitative*' and '*State Information*' respectively.

'*Quantitative Information*':

If I hold one helium atom in my hand, no one in the entire universe will see me hold more than one atom, nor would anyone see me holding a different type of atom since the number of constituents (i.e., protons, neutrons, and electrons) is *Information* and thus is found universally equal.
This demonstrates that '*Quantitative Information*' is universally equal, and valid without dispute. It is 'available'. Thus, the *Information* itself does not travel. However, at large distances from the source it may not yet be 'accessible'.

'*State Information*':

Today I may observe the implosion of a star as it reached the end of its life. Say, it happened in deep space, 50 lightyears away. From my observation I conclude, that based on my local clock, the star imploded 50 years ago.
Yesterday, that '*State Information*', though existing, was not 'accessible' to me. But today, with the arrival of the associated light, the *Information* became accessible. If I had been asked yesterday whether the star had imploded, the correct answer could only have been: 'I don't know'. But today, based on observation, I do also -and in retrospect- know the answer to yesterday's question: it imploded.
The point here is that, since the local moment of implosion, the *State Information* instantaneously was universally *available.* However, 'available' is not synonymous with 'accessible'. I was in the blind for the single reason that the trigger that made it accessible (carried by light/*Photons*) had not yet arrived.

The *Crenel Physics* modelling whereby *Information* is universally 'available' without always being 'accessible' embeds a scientific challenge. Are there ways to break through that barrier?

Science found ways. Based on Newton's laws, for example, within the limits of our observation accuracy we can make *Information* accessible with regards to past and future positions of planets. Per the *Crenel Physics* model, such *Information* is universally 'available', and per Newton it describes a true smoothness of unfolding as *time* proceeds. Or: the smoothly unfolding future of planet positions is already determined, as their past has been written. All this *Information* is -with limited observation accuracy- available anywhere and now.

Generalizing this viewpoint is controversial between scientists. Einstein took a confirming position by summarizing it as: 'God does not gamble'. We can tone this viewpoint down based on Boltzmann's theory. Per this theory, all our observations are *state* observations and the difference between two states is quantified in *bits*. Thus, for any state observation there is a minimum *state uncertainty* of ½ *bit*. A larger *state uncertainty* would make our observation jump towards another state version. Consequently, even with the greatest (theoretically possible) precision, it is impossible to remove all *uncertainty* from any observation.

> *Later in this chapter we use this finding to explain 'Heisenberg's uncertainty principle'.*

The inherent minimum uncertainty in our observations leaves an input error in any modelling of physical outcomes, even when we believe that there can only be one single future (as Einstein did). Presuming an underlying truly smooth and precise unfolding of events, there is only one single future scenario.

However, the inability to extrapolate future (or past) data without *uncertainty* is not equivalent to suggesting a 'gambling' component. Rather:

(34) Per the *Crenel Physics* model, nature unfolds truly smoothly, whereas our observations unavoidably are subject to uncertainty.

Finally, the idea that we might not have to wait for arriving light or radio signals to reveal *Information* from remote areas is intriguing. Conceptually, per the *Crenel Physics* model we may find triggers that make it accessible. Quantum physics demonstrated such a trigger in practice. In the associated terminology: coupled quantum particles can communicate between them at 'infinite' velocity.

d) Information Building Blocks

We classified '*Information Storage Capacity*' as a 'hardware' property and found *Entropy* its universally equal measure.

To learn more about this hardware, we define the '*Information Building Block*':

(35) An '*Information Building Block*' is an entity that can reside in a predefined, finite natural number of states ('w_{ibb}').

In the case of a single *State Information Building Block,* within equation (4.1) the term: $ln(w)=ln(w_{ibb})= ln(1)=0$. Per this equation, the *Entropy* value '*S'* then also equals 0. Single *State Information Building Blocks* therefore cannot be used to construct an entity with some non-zero value for embedded *Entropy* '*S'*.

To construct *Entropy,* we must use *blocks* that can reside in at least two potential states (i.e., the *bit)*.

There are no options to construct, out of smaller pieces, an *Information Building Block* that could reside in 3 states as:

1. It could not be composed of three *Blocks* that each can reside in one single *state*, as the combination could still only reside in one single *state*.
2. It could not be constructed of a combination of one binary *Block* plus one single *state Block* as the addition of the latter -again- does not impact the number of potential states.
3. A combination of 2 *binary Blocks* overshoots as it can reside in 4 states.

The only solution would be a single 3-*state Block*.

This likewise holds for *Blocks* with 5, 6, 7, or 9 potential states, for example, where no combination of smaller *Blocks* can be used. (8 states can be composed of 3 binary *Blocks*).

In Chapter 12, we will argue why 2-state Blocks (bits) are natures default, whereas the shaping of other sized Blocks is unlikely.

The 'hardware' of some large entity can be described as one single *Information Building Block*. Alternatively, it then can be described as an aggregation of the smallest usable *blocks*, that is, *bits*.

(36) Any existing *Entropy* can be described as an aggregate of individual *bits*.

Per added *bit* the potential number of states doubles, so that the options for parameter *w* in Boltzmann's equation are confined to values of the exponential function 2^n, whereby *n* is a *counting number* ≥1.

e) The nat

We established the *nat* as the 'natural' *UoM* for *Information.* But what makes the *nat* 'natural'?

To find the answer we review Boltzmann's equation $S = k_B . ln\,(w)$, thereby seeking *normalization*.

For finding *normalization*, let us use a quantity of 'n' *bits* to construct an *Entropy 'S'*. We meet the *normalization* goal if the *Entropy* (in *bits*) equals the number of *bits* that we used.

The goal:

$$\boldsymbol{S_{(bit)} = n\,(bits)} \qquad (4.2)$$

To calculate the *Entropy* thereof in *bits*, we substitute the above specification of *n bits* into equation (4.1):

$$\boldsymbol{S_{(bit)} = k_{B(bit)} . ln(2^n) = k_{B(bit)} . n . ln(2)} \qquad (4.3)$$

Recall that *Entropy* '*S*' and Boltzmann's constant 'k_B' must have the same *UoM*, so that we must use the *bit* version of 'k_B' as shown.

In comparing our goal per equation (4.2), with the calculated value per equation (4.3), our *normalization* goal demands that the term '$k_{B(bit)}.\ln(2)$' in equation (4.3) matches the numerical (=*quantitative*) value '1':

$1 = k_{B(bit)} . ln(2)$

The term '$k_{B(bit)}.\ln(2)$' at the right side of this equation is expressed in '*bit*'. For dimensional integrity, the numerical value of the left side ('1') then likewise must be expressed in some

Information UoM. Because the latter *UoM* stands for the *normalized* version, we named it the '*nat*': the **natural** *UoM* for *Information*. Thus, more explicit:

1 *nat* = $k_{B(bit)}.\,ln(2)$

As the *bit* was found the quantum for *State Information*, the *nat* is its counterpart:

(37) The *nat* is the normalized *UoM* (= unity) for expressing *Quantitative Information*.

As discussed, Boltzmann's constant k_B is equal to 1 *nat* as well as 1.442695 *bit*.

Per the above, if we multiply the latter value with *ln(2) = 0.693147* we indeed get value 1:
$1.442695 \times ln(2) = 1.442695 \times 0.693147 = 1$

When expressed in *bits*, the exact numerical value of Boltzmann's constant is equal to *1/ln(2)*.

Note that we 'reverse engineered' the *nat* by basing its value on the *bit* and demanding *normalization*.

By alternatively using the digit rather than the bit, we would have the same outcome:
1 nat = $k_{B(digit)}.\,ln(10)$.
When expressed in digits, the exact numerical value of Boltzmann's constant is equal to 1/ln(10).

f) Additional Versions of Planck's Constant h_{cp}

In Chapter 1, equation (1.3), we defined Planck's constant h_{CP} as the inner product of *Content* and *Whereabouts*:

$h_{CP} \equiv 1\; C.P$

We addressed the orthogonality between *Content* and *Whereabouts* (Chapter 3) and thereby found that -by inverting- we can exchange *Whereabouts* for *Content* -and vice versa- without violating the conservation principle.

Given this, based on *Information* being the third independent physical property as well as the *nat* being its natural *UoM*, we can now define both the inner product of respectively:

- ✓ *Content* and *Information*

And

- ✓ *Whereabouts* and *Information*

This leads to two additional Planck-like universal natural constants. Using symbol '*I*' for *Information* (in *nat*) we define these as:

$\boldsymbol{h_{PI} \equiv 1\; P.I}$	4.4

And:

$\boldsymbol{h_{CI} \equiv 1\; C.I}$	4.5

The above likewise implies that we can exchange *Whereabouts* for *Information* (and vice versa) as well as *Content* for *Information* (and vice versa). These are consistent enhancements to the previously described 'ultimate view on the conservation principle' (Chapter 3).

The following illustrations of exchangeability demonstrate that the implications are trivial and indeed hold true:

1. One *kg* is equal to 2 half-*kg*.
   In the latter we doubled the *Quantitative Information* while taking half the *Content* without making a difference, thus without violating the conservation principle.
2. One meter is equal to 2 half-meters.
   In the latter we doubled the *Quantitative Information* while taking half the *Whereabouts* without making a difference, thus without violating the conservation principle.

g) All Options for k_B are Equal

The four listed options of k_B address the same physical fact. The equalities…

$\boldsymbol{k_{B(nat)} \equiv k_{B(bit)} \equiv k_{B(Hz/K)} \equiv k_{B(J/K)}}$	4.6

…demand unambiguous universal relationships between them. Let's explore these.

We already addressed the conversion factor (*ln(2)*) between the two given microscopic versions $k_{B(nat)}$ and $k_{B(bit)}$. Let's focus on the two macroscopic versions.

Prior to further analysis, we first make a sidestep and highlight the following general requirement:

(38) The *UoM* of a universal natural constant must be universally equal.

Consider, for example, light velocity 'c' which is a universal natural constant. To all observers it has been set equal to 299,792,458 m/s. Therefore, unlike the 'meter' and the 'second' themselves, per the above requirement the ratio 'm/s' must be universally equal, as is the Information part (299,792,458).
One could argue that it is a feature of Photons that causes this equal appearance of the m/s. From an objective perspective this leaves room for a hypothetical theory that in general such universal equality is not valid. Lacking arguments for or against this scenario, we will ignore it.

Within any system of *UoM's*, any ratio between any two *UoM's* of universal natural constants then must also be universally equal.
For example, within *Metric Physics* the ratio between the two macroscopic options for k_B in *J/K* and *Hz/K* respectively: $\frac{\frac{J}{K}}{\frac{Hz}{K}} (= \frac{J}{Hz})$ must be universally equal. The $\frac{J}{Hz}$ matches the *UoM* of Planck's universal natural constant '*h*', and for that reason must indeed be universally equal. We can alternatively express it as:

$\frac{J}{Hz} = \frac{J}{second^{-1}} = J.s.$

Metric Physics typically expresses Planck's constant *h* in *J.s*:

$h = 6.62607015\ldots \times 10^{-34}$ *J.s*.

The consistency of this value can be verified within the *Metric Physics* system where '*h*' then must equal $k_{B(J/K)}/k_{B(Hz/K)}$:

$$(6.62607015 \ldots \times 10^{-34}\, J.s) = (1.3806488 \ldots \times 10^{-23}\, {}^{J}/_{K}) \div (2.0836618 \ldots \times 10^{10}\, {}^{Hz}/_{K})$$

The above holds true as expected, so that we found Planck's constant *h* to represent the conversion factor at hand: $k_{B(J/K} = h.\, k_{B(Hz/K)}$.

Crenel Physics normalizes this same ratio. Here, the afore mentioned $\frac{J}{Hz}$ converts to $\frac{P}{C^{-1}} = P.C$, and Planck's constant h_{CP} indeed equals 1 *P.C* (see equation (1.3)).

To now explore the relationship between the two macroscopic measures (*J/K* and *Hz/K*) and their microscopic counterparts (*nat* and *bit*), we must introduce the *UoM* for *temperature*.

As mentioned in Chapter 1, *Metric Physics* defines the *UoM* for *temperature* as follows:

$\mathbf{1\ UoM\ (Temp.) = \frac{UoM\ (Energy)}{k_B}}$	4.7

Here, *energy* is expressed in *Joule*. So, to ensure dimensional integrity in the above equation, we must use the $k_{B(J/K)}$ version for Boltzmann's constant. The *UoM* for *temperature* in equation (4.7) then is the *Kelvin* (*K*).

From the *Crenel Physics* perspective, *Energy* is one of the *Appearances* of *Content*. Equation (4.7) therefore expresses a circular reference between the *UoM's* for *Content*, *temperature,* and the various options for Boltzmann's constant. We generalize this circular reference as follows:

(39) To any version of Boltzmann's constant, one can associate an *Appearance* for *Content* which then must lead to the same measure for *temperature*.

We do not know how many versions of Boltzmann's constant can be provided by nature. Given the above, it certainly would help if we knew them all.

Consider that in Chapter 2 we found *frequency* to be an *Appearance* of *Content*. Based on the above generalization we can now alternatively define the *UoM* for *temperature* as:

$\mathbf{1\ UoM\ (Temp.) = \frac{UoM\ (Frequency)}{k_B}}$	4.8

Metric Physics expresses *frequency* in *Hertz*. Here again we must ensure dimensional integrity, in this instance by using the $k_{B(Hz/K)}$ version of Boltzmann's constant.

Temperature is associated with a *frequency* of *state* swapping within an object. To discuss a measure for *temperature* and establish our basis, we must first differentiate between *frequency* and *angular frequency*.

In Boltzmann's equation (4.1) the number of states '*w*' is a natural number. *Frequency* then quantifies the rate of *state* changes per *time UoM*. With Boltzmann's universal natural constant being based on full switches between discrete states, we have a decisive argument for consistently basing *Crenel Physics* on *frequency* rather than on *angular frequency*.

(40) *Crenel Physics* is *frequency* based.

For completeness, we now add the *Metric Physics* definitions for the *temperature UoM* based on the *nat* and *bit* versions of k_B. Thereby we ensure the required dimensional integrity.

For k_B= 1 *nat*:

$$\mathbf{1\,K = \frac{nat.K}{k_{B(nat)}}} \quad (4.9)$$

And for k_B= 1 *bit*:

$$\mathbf{1\,K = \frac{bit.K}{k_{B(bit)}}} \quad (4.10)$$

The added value of equations (4.9) and (4.10) is that the terms '*nat.K*' and '*bit.K*' within these equations are additional *Appearances* for *Content*.

Per equation (4.9), for entities with an *Entropy* value of 1 *nat*, the *Kelvin* itself is a measure for *Content* (since $k_{B(nat)}$ = 1).

Should we express that same *Entropy* in *bit*, per equation (4.10) we will find that same temperature in *Kelvin*.

We will revisit the two *Appearances* '*nat.K*' and '*bit.K*' later to discuss in greater detail. Here we found that '*temperature* as an *Appearance* of *Content*' only holds true for objects with an *Entropy* value of 1 *nat*. For example: 2-*nat* objects reach that same *Content* at half the *temperature* (in *Kelvin*)

In *Crenel Physics* the *Package* is the one and only *UoM* for *Content*. Here, equation (4.7) translates to:

$$\mathbf{1^0\,T_{CP} = \frac{Package}{k_B}} \quad (4.11)$$

We can verify that this equation is consistent with *Metric Physics* by substituting equation (1.9), the conversion from *Package* to the *Metric Physics energy UoM*, into the equation and by using the *Metric Physics J/K* version $k_{B(J/K)}$. In doing so we find the conversion factor from the *UoM* of T_{CP} to *Kelvin*:

$$\mathbf{1^0 T_{CP} = \sqrt{\frac{h.c^5}{G.(k_{B(J/K)})^2}}\ (Kelvin)} \quad (4.12)$$

= 3.5515x10[32] *K*

Again, this *UoM* resembles a 'Planck Unit' (here: for *temperature*). As before, we see *'h'* instead of $'\hbar'$ in the equation (see also equation (1.14)). Recall that *Crenel Physics* is *frequency* based while Planck units are based on *angular frequency*.

Using the above we can now convert $k_{B(nat)}$ to $k_{B(Hz/K)}$. To find the conversion factor we divide the *Crenel Physics* conversion factor from *Package* to *Hz* per equation (1.11)…

$$1\ Package = \sqrt{\frac{c^5}{h.G}}\ (Hertz)$$

…by the *Crenel Physics* conversion factor from T_{CP} to *Kelvin* per above equation (4.12).

The result indeed equals the macroscopic value for $k_{B(Hz/K)}$ as found in *Metric Physics*:

$$\mathbf{1(nat) \equiv \frac{\sqrt{\frac{c^5}{h.G}}}{\sqrt{\frac{h.c^5}{G.\left(k_{B(J/K)}\right)^2}}} = \frac{7.4001x10^{42}\ Hz}{3.5515x10^{32}\ K} = 2.08366 \times 10^{10}\ (Hz/K) = k_B(Hz/K)} \quad (4.13)$$

Similarly, the *J/K* version $k_{B(J/K)}$ is found by dividing the *Crenel Physics* conversion factor from *Content* to the *energy Appearance* per equation (1.9)…

$$1\ Package = \sqrt{\frac{h.c^5}{G}}\ (Joules)$$

= 4.9033x10[9] *J*

…by the *Crenel Physics* conversion factor from T_{CP} to *Kelvin* per equation (4.12):

$\mathbf{1}(\boldsymbol{nat}) \equiv \dfrac{\sqrt{\frac{h.c^5}{G}}}{\sqrt{\frac{h.c^5}{G.\left(k_{B}(J/K)\right)^2}}}$ $= \dfrac{4.9033\times10^{9}\,J}{3.5515\times10^{32}\,K}$ $= 1.3806 \times 10^{-23}\ (J/K)$ $= k_{B}(J/K)$	4.14

Again, our result is consistent with *Metric Physics*.

This completes our search for universal equality between microscopic *Entropy UoM's* (*nat* and *bit*) and macroscopic *Entropy UoM's* as found within *Metric Physics* (*J/K* and *Hz/K* respectively).

h) Additional Appearances of Content

Based on the four listed *UoM*-options for k_B at the beginning of this chapter and thereby for *Entropy* '*S'*, within the *Metric Physics* system, we now have as many *Entropy*-based routes to *Content*:

$\boldsymbol{Content(J)} = \boldsymbol{T(K)} \times \boldsymbol{S}(J/K)$	4.15
$\boldsymbol{Content(Hz)} = \boldsymbol{T(K)} \times \boldsymbol{S}(Hz/K)$	4.16
$\boldsymbol{Content(bit.K)} = \boldsymbol{T(K)} \times \boldsymbol{S(bit)}$	4.17
$\boldsymbol{Content(nat.K)} = \boldsymbol{T(K)} \times \boldsymbol{S(nat)}$	4.18

To construct *Content* in the above equations, we multiply an objects 'hardware' property *Entropy* (universally equal) with the 'software' parameter *temperature* which is subject to the *Theory of Relativity*.

We can universally convert *temperature T(K)* to *Hz* by reviewing the respective universal *UoM* for *temperature*. Equations (4.12) and (1.11) show that if one multiplies the *UoM* for *temperature* with a universal conversion factor equal to…

$\dfrac{k_{B}(J/K)}{h}$	4.19

… the outcome is *Hz* (= the *frequency UoM*).

Using this conversion factor, we can assign a *temperature* to an object based on its *frequency*:

$\dfrac{k_{B}(J/K)}{h} \times T = v \quad or: \quad T = \dfrac{h}{k_{B}(J/K)} \times v$	4.20

Equation (4.20) was applied in Chapter 2. Pending an objects *Entropy*, it provides a universal method to determine that objects *temperature T(K)* by measuring its *frequency*.

Using the conversion factor from *temperature* to *frequency* given by equation (4.19)…

$$\frac{k_{B}(J/K)}{h}$$

…we can 'reverse engineer' equation (4.18)…

$\boldsymbol{Content(nat.K)} = \boldsymbol{T(K)} \times \boldsymbol{S(nat)}$	4.21

…from *Content* (*nat.**K***) to *Content* (*nat.**Hz***):

$\boldsymbol{Content(nat.Hz)}$ $= \dfrac{k_{B}(J/K)}{h} \times \boldsymbol{T(K)} \times \boldsymbol{S}_{(nat)}$	4.22

Here per equation (4.20), the term…

$$\frac{k_{B}(J/K)}{h} \times T(K)$$

…equals *frequency* 'v'. We thus find:

$\boldsymbol{Content(nat.Hz)} = \boldsymbol{v} \times \boldsymbol{S}_{(nat)}$	4.23

This equation shows that *Content* is not only proportional to *frequency*, but also proportional to an objects *Entropy* in *nat*.

Based on Planck's equation $E = h.\upsilon$, the above *Content* (in *nat.Hz*) can be converted to *Content* (in *J*) by multiplying it with Planck's constant. Equation (4.23) then converts to:

$$Content(J) = h \times \upsilon \times S_{(nat)}$$

Or:

$$\boldsymbol{E = h.\upsilon.S_{(nat)}}$$	4.24

Equation (4.24) is an enhancement to Planck's equation $E = h.\nu$ (which applies to *Photons* only) and is applicable to particles with any *Entropy* value. In Chapter 5 we will explore this further.

We will refer to equation (4.24) as the '*enhanced Planck equation*'.

i) Heisenberg

Earlier we found that the *bit* is the leanest amount, thus 'quantum' for *State Information*, thus for resolving *State Uncertainty*. Furthermore, the difference between two states always must equal a counting number thereof, thus a counting number of the normalized *Quantitative Information UoM*, i.e.: the natural *UoM* for *Information*, alias the *nat*, alias Boltzmann's constant.

We can now precisely define the minimum difference between two states of a system:

(41) The minimum difference between two states of a system equals the *UoM* for *Quantitative Information* (i.e.: the *nat*) multiplied with the *UoM* for *State Information* (i.e.: the *bit*).

This minimum inherently introduces a '*State Uncertainty'* equal to ½-*bit* as, should the *uncertainty* exceed ½ *bit*, the observed state would then jump to another (closer) state option. This minimum *state uncertainty* is universally equal.

This minimum *uncertainty* is regardless the potential number of potential *states* of a system. Therefore, it implies an '*absolute ½-nat **quantitative** uncertainty*' applicable to any observation or measurement.

There is yet another consideration. Per the *Crenel Physics* model, we found that *Content* equals inverted *Whereabouts*. Thereby, for any value of either *Content* or *Whereabouts*, the product *P.C* must remain constant (i.e., it is equal to the *Crenel Physics* version of Planck's constant h_{CP}). Consequently, some given *uncertainty* in the *Content* of an object automatically defines the *uncertainty* in its *Whereabouts* (and vice versa):

(42) The errors in *Content* and *Whereabouts* are symmetrical because the product of *Content* and *Whereabouts* is constant.

We define the absolute error ΔP (*Packages*) in the *Content* arena and a corresponding inverse error ΔC (*Crenel*) in the *Whereabouts* arena. Based on the above, the product $\Delta P.\Delta C$, which represents the combined *state* error, is a constant.

Per the *Crenel Physics* model, the *uncertainty principle* can now be formulated:

(43) The observed product of a *Content Appearance* and a *Whereabouts Appearance* embeds a minimum *state uncertainty* equal to ½ *bit*, which corresponds to a minimum *quantitative uncertainty* equal to ½ *nat*.

The *uncertainty* principle per the *Crenel Physics* model thus can be written as:

$$\boldsymbol{\Delta P.\Delta C = \frac{h_{CP}}{2}}$$	4.25

This equation is the *Crenel Physics* version of Heisenberg's *uncertainty principle*.

Within *Metric Physics* the amount of *uncertainty* equals $\hbar/2$, not $h/2$ as it is shown in the above equation. The *Crenel Physics* model explains the absence of the factor 1/2π by being *frequency* based. The consequence is that in *Crenel Physics* all 'Planck units' embed *h* rather than $\hbar$. Equation (4.25) therefore is consistent with Heisenberg's *uncertainty principle* as found in *Metric Physics*.

(5) Photons

Photons meet Planck's equation $E = h.\nu$.
As with any particle they must also meet the 'enhanced Planck equation' (4.24):

$E = h.\upsilon.S_{(nat)}$

For the latter, the 'intrinsic' *Entropy* value $S_{(nat)}$ of a single *Photon* must equal 1 *nat*; that is, must equal Boltzmann's constant. The term 'intrinsic' expresses that this value is not dependant on any other potential property or circumstance. This is consistent with our categorization of *Entropy* as a 'hardware' property.

(44) *Photons* have an intrinsic *Entropy* equal to 1 *nat* (= Boltzmann's constant)

In *Metric Physics,* individual *Photons* are generally not described as *Entropy* embedding entities. But the idea is not new. Reference [1] presents a viewpoint for '*Intrinsic Photon Entropy*' in which an *Entropy* value for *Photons* is argued though not quantified.

Let's verify the 1 *nat Entropy* value for consistency. Consider a general thermodynamic principle: the *heat* embedded within an object equals its absolute *temperature* multiplied with its *specific heat* value.

Experiments show that when a 'blackbody' absorbs *Photons* it will warm up. The absorbed *Photons* completely vanish. The *heat* influx as well as the associated temperature rise of the blackbody match the *energy* as embedded by the absorbed *Photons*. This *energy* then fully takes the shape of *heat*.

To verify this for consistency with our findings, we use equation (4.18) which came forth from Boltzmann's theory…

$Content(nat.K) \ = T(K) \ \times S(nat)$
… and substitute 1 for *nat*, and 1 for *S(nat)* to apply it to *Photons*:

$\boldsymbol{Content(K) = T(K)}$	5.1

(1 nat objects)

In *Metric Physics* a *Photon's frequency* (and thereby *energy*) can be expressed as, or converted to a *temperature* by using equation (4.20):

$$T = \frac{h}{k_{B(J/K)}} \times \upsilon$$

However, *Metric Physics* is not normalized, and a numerical verification requires a calculator (for most of us).

Within the *Crenel Physics* model equation (5.1) is normalized (Chapter 2):

$\boldsymbol{Content_{(Packages)} = T_{(CP)}}$	5.2

(1 nat objects)

Within *Crenel Physics*, for 1 *nat* objects we can - without impact to the numerical value (expressed in *Packages*)- swap with any other *Appearance* of *Content*. By using equation (5.2), we will swap from the *temperature Appearance* 'T_{CP}' to the *frequency Appearance*.

Per equation (4.20) we then must multiply 'T_{CP}' with the *Crenel Physics* version of Planck's constant 'h_{CP}', which as we saw has a value equal to 1 (recall that $h_{CP} = 1$ *P.C* ≡ 1), to divide the result by Boltzmann's constant, which also has a value of 1. Dimensionally, this multiplication results in a swap from *frequency* (expressed in *Crenel*$^{-1}$) to *Content*:

$Content_{(Packages)} = T_{(CP)} = h_{CP}.\nu_{CP}$

The above matches Planck's equation $E = h.\nu$, which indeed applies to *Photons*. We can thus conclude that the *Photon's Entropy* value of 1 *nat* consistently bridges equation (4.18) (coming forth from Boltzmann's theory) with Planck's equation $E = h.\nu$.

Finding that each *Photon* embeds a fixed 1 *nat* of *Entropy* impacts views on known experiments:

(45) Where *Photons* flow, *Content* flows <u>and</u> *Entropy* flows.

Let's explore the implications.

a) The Second Law of Thermodynamics

"The sum of the Entropies of initially isolated systems is less than or equal to the total Entropy of the final combination."

Because *Photons* embed *Entropy,* they therefore become part of the game.

For each *Photon* absorbed, we will lose 1 *nat* of *Entropy*. Yet, per the second law of thermodynamics, such *Entropy* loss must -in the final combination- be restored and possibly exceeded.

Let's examine two ultimate scenarios, created when we shine a light on (and thus radiate *Photons* to) an object:

1. The object acts as a perfect mirror. The number of incoming *Photons* exactly matches the number of outgoing *Photons* so that there is no net impact on the *Entropy*. The minimum requirement of the second law of thermodynamics is met.
2. The object acts as a perfect 'blackbody'. All incoming *Photons* are absorbed and thereby their embedded *Entropy* disappears. Given that the *Entropy* of the blackbody (being a 'hardware property') will not change, through some mechanism recovery is demanded at some point in time. The law applies to a 'final combination'.

So, let's explore this second scenario in more detail. Due to the absorption of the *Photon's* embedded *heat*, the blackbody will warm up. Consequently, it will increase its radiation (i.e., increase the number of emitted *Photons)*. Thereby, per extra emitted *Photon* 1 *nat* of *Entropy* is restored. At some point in time this will result in an equilibrium and the *temperature* rise will stop. Based on the *energy* conservation law, from then onwards *heat in = heat out*.

We could now conclude our analysis by supposing that 'that's all'. But there is more to learn.

Metric Physics says that the blackbody will give off its 'own' emission spectrum regardless the heat source. See the figure below:

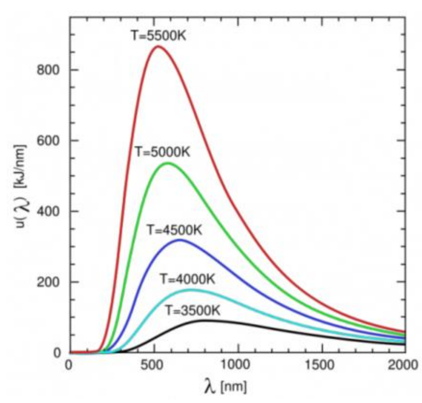

Fig. 5.1: Photon Emission Spectrum of a Blackbody
Credit: Wikipedia.

As the figure shows, the emission curve is exclusively based on the *temperature*. This suggests that there is no relationship whatsoever between the nature of the heat source (here the absorbed *Photons*) and the emitted *Photons*. However, finding that *Photons* embed *Entropy* means that the second law of thermodynamics comes into play. But how?

Experimental data, as Figure 5.1 illustrates, shows that the emission spectrum of a blackbody is continuous, with a peak at a specific wavelength. As the blackbody's *temperature* rises, this peak moves to shorter wavelengths and the spectrum's intensity increases.

If then *Photons* embed *Entropy*, this imposes a constraint to the absorption/emission balance. Here we see the second law of thermodynamics at work. To meet it:

$$n_{emitted} \geq n_{absorbed} \tag{5.3}$$

We use symbols $E_{avg\text{-}emitted}$ and $E_{avg\text{-}absorbed}$ for the average *energy* of the emitted and absorbed *Photons* respectively. At thermal equilibrium and in the absence of any other *energy* source, the *energy* conservation law demands:

$$n_{emitted} \cdot E_{avg-emitted} = n_{absorbed} \cdot E_{avg-absorbed} \tag{5.4}$$

To meet the requirements of both equations (5.3) and (5.4):

$$E_{avg-emitted} \leq E_{avg-absorbed} \tag{5.5}$$

Equation (5.5) must apply in all *Photon* absorption/emission cases at equilibrium. Let's zoom in on some more detailed scenarios.

Scenario #1:

We direct monochromatic light (where all *Photons* have equal $E_{avg\text{-}absorbed}$) toward an object. At thermal equilibrium, per equation (5.5), the average *Photon energy* as found within the emission spectrum

$E_{avg\text{-}emitted}$, must be equal to or less than the fraction absorbed. This requirement puts a cap on the ultimate *temperature* of the blackbody.

Scenario #2:

Consider a blackbody residing in empty space. *Heat* transfer thus is by radiation only. Being an ideal blackbody, it should absorb all arriving *Photons*. We use a monochromatic light source with two variables:

1. The light *intensity* which sets the maximum value of $n_{absorbed}$ for the blackbody.
2. The light *frequency* υ which sets the value of $E_{absorbed}$ for the *Photons* to be absorbed by the blackbody.

The blackbody thus is subject to a heat influx:

$$\boldsymbol{heat_{in} = n_{absorbed} \times E_{absorbed}} \quad (5.6)$$

It makes no difference to the influx of *heat*, should we reduce the *frequency* of our light source while simultaneously and proportionally increasing the *intensity*.

Per the *Metric Physics* model (whereby *Photons* are not presumed to embed *Entropy*), this exchange should have no impact on the ultimate *temperature* and therefore emission spectrum of the blackbody. However, the *Crenel Physics* model imposes a constraint per equation (5.5).

Presume that we reduce the light source's *frequency* (and thereby $E_{absorbed}$) while proportionally increasing the *intensity* (and thereby $n_{absorbed}$). Although this exchange does not impact the total incoming *heat* flow, it must ultimately throttle back the average *frequency* (and thereby $E_{avg\text{-}emitted}$) of the emission spectrum.

Figure (5.1) shows a one-to-one exclusive relationship between a blackbody's radiation spectrum (and thereby the value of $E_{avg\text{-}emitted}$) and its *temperature*. To maintain that *temperature* requires a *heat* input that matches the emission thereof. Should we now increase the intensity of our light source beyond the emission intensity, the *Crenel Physics* model demands that this cannot result in a further *temperature* rise of the blackbody. The extra *Photons* will be mirrored. From this we conclude:

(46) The *temperature* of a *Photon* absorbing/emitting object can reach but not exceed the *temperature* of the incoming *Photons*.

The inescapable consequence of this equation is that net *heat/energy* flow between two objects, when carried by *Photons*, can only flow from the higher *temperature* object towards the lower *temperature* object.

It is the *Entropy* embedded within *Photons*, in combination with the second law of thermodynamics, that jointly demand this.

Then what drives the blackbody to start radiating? Surely this cannot be a *temperature gradient*. Our experiment is performed in an otherwise empty space, so there is no *temperature gradient*.

The *Crenel Physics* answer to this question is based on the finding that *Photons* have *Entropy.* The subsequent hypothesis is that the second law of thermodynamics is providing the driving force: it drives toward recovering (or even creating additional) *Entropy*.

When seen from this perspective, if then a *Photon* would **not** embed *Entropy*, there would be no drive for the black body to start radiating.

(47) Black body radiation is driven by the second law of thermodynamics.

This model also is consistent with, for example, the experimental finding that two *Photons* never 'team up' to boost potential beyond their individual capabilities. For exciting an electron within an atom, for example, a certain amount of *energy* is required. That *energy* must come from one single *Photon* only. A group of *Photons* teaming up to deliver that *energy* is not seen. Per our model, it is not a valid option: relative to the single *Photon* case this would result in extra loss of *Entropy.* In terms of *Entropy* recovery such extra loss would have no beneficial consequences to subsequent events.

(6) Observing

Per Boltzmann's theory, in any snapshot observation of an object we will find it residing in one of its potential states.

Should there be one single potential state option ($w=1$ in Boltzmann's equation (4.1)), the conservation laws would not have relevancy since in all cases the object would be found in the same state. Without the potential for responding to an event, such object by itself could not 'conserve' anything at all.

Hypothetically, it may reveal its existence when physically colliding with a sensor. However, per Boltzmann's equation (4.1) such a single state object would have an *Entropy* value $S = 0$. Consequently, per equations (4.15 thru 4.18) it would embed no *Content*. As such, it seems unlikely that even a physical collision would have an impact.

To allow interaction (or better: to play a role in the conservation laws that apply to any interaction), an object must have a minimum of two potential states. This demands that the minimum *Entropy* thereof is equal to 1 *bit*.

For this we define the *Mono-Bit*:

(48) A *Mono-Bit* is the leanest option for interaction. It has an *Entropy* value of 1 *bit*.

When placed in an empty space and in lack of internal interaction options, it would be frozen in one of its two potential states.

a) Observable versus Verifiable

Should we now introduce a sensor into the scenery, due to some remote mechanism it may start interacting with a *Mono-Bit*. Such interaction then would represent the sensing. Thereby the process that we are monitoring **is** the sensing. As soon as we would stop the sensing (by removing the sensor) the *Mono-Bit* would freeze again, and whatever we were observing vanishes.

Given the above we define *observability*:

(49) An object is *observable* when it can remotely interact with a sensor, changing the *state* of the sensor.

For *verification* we must demand more. Whatever we observe was already ongoing (one way or the other) before we started our observation, and it must continue (one way or the other) thereafter. This feature ensures that we can reconcile past parameters that describe the observed, and that we can predict/verify the future thereof.

b) The Entropy-Atom

Verification demands that an object, when left alone in an otherwise empty space, can embed *Content*. This then requires that it can reside in more than one *state* without violating the conservation principles. And if indeed *state* changing at some *frequency*, per enhanced Planck's equation (4.24), it will indeed embed *Content*.

(50) An object is *verifiable* when it can embed *Content* in an otherwise empty space.

To meet this requirement a *verifiable* object must embed an *Entropy* value of at least two *bits*. Thus, if one of the *bits* changes its *state*, the other can compensate the consequences thereof (whatever these may be) so that they jointly can uphold a durable *frequency*, thus *Content*.

We will name this leanest *verifiable* object an *Entropy-Atom*.

(51) The *Entropy-Atom* is the leanest object that can be *verified*. It has an *Entropy* value of 2 *bits*.

Note that the term '*atom*' reflects that anything of lower *Entropy* value cannot be verified.

c) Photons are the Exception

Photons were found to have an *Entropy* value of 1 *nat*, which is equivalent to approximately 1.4 *bit*. This *Entropy* value explains why Boltzmann's equation (and theory) does not apply here. We started this chapter with: 'Per Boltzmann's theory, in any snapshot observation of an object we will find it residing in one of its potential states'. By -hypothetically- taking a snapshot of a *Photon*, we would not be able to find it in some 'state'. In fact, any observation effort will permanently destroy it. We can only verify the 'birth' of a *Photon* indirectly: by verifying the impact thereof at its source. And likewise, we can only indirectly verify the 'death' of a *Photon* by verifying the impact on its target. Thus, we can -indirectly- count the number of emitted or absorbed *Photons*. But during a *Photon's* lifetime we are in the blind.

There is a logical argument for concluding that such counting is only possible thanks to their inherent *Entropy* of 1 *nat*. Without this *Entropy*, what exactly would we be counting? Without *Entropy*, how could a *Photon* embed *Content*?

Obviously, *Photons* shape a different league within our model. This is illustrated by their special properties that could not possibly apply to 'regular' matter. For example: they always are found to travel at light velocity.

d) Recalibration

In the material world the demand for remote *verification* is justified. Without this option we can neither predict anything, nor reconcile anything. The requirements for *verification* make evident that our observations are restricted. As it stands, we are not able to verify all that may happen. Furthermore, we must recalibrate our equations so that they cover both the *verifiable* as well as the *unverifiable*.

The need for recalibration becomes obvious when we evaluate Planck's equation $E = h.\upsilon$, which applies to *Photons* but does not apply to *Entropy-Atoms*. In the latter case we must use the enhanced version of Planck's equation (4.24):

$E = h.\upsilon.S_{(nat)}$

The *Entropy-Atom's Entropy* value of *2-bits* is equal to:

2 bits = 2.ln(2) nat = ln(4) nat = ln(4).

The *Content* of a smallest possible *verifiable* object (the *Entropy-Atom*) equals:

$\boldsymbol{Content(J) = h \times \upsilon \times ln\,(4)}$	6.1

Thus, when applying the enhanced Planck equation, the value of Planck's constant does not need to be modified. It will then apply to both *Photons* as well as objects with higher *Entropy* values, such as the *verifiable Entropy-Atom*.

e) The Entropy-Atom's Content Yardstick

Equation (4.18)…

$Content(nat.K) \;=\; T(K) \;\times S(nat)$

… gives an alternate Boltzmann-based route to finding *Content*.

Substituting for *S(nat)* the *Entropy* value of an *Entropy-Atom* gives:

$\boldsymbol{Content(nat.K) \;=\; T(K) \;\times \ln\,(4)}$	6.2

(for *Entropy-Atoms*)

For *Entropy Atoms* we can simplify equation (6.2):

$\boldsymbol{Content(K) = T(K) \times \ln\,(4)}$	6.3

(for *Entropy-Atoms*)

In this equation we can substitute the *UoM* for *temperature* per equation (4.12):

$1^0T_{CP} = \sqrt{\frac{h.c^5}{G.(k_{B(J/K)})^2}}$

Thus, the associated *Content UoM* for *Entropy-Atoms*, expressed in *Packages* equals:

$\boldsymbol{1\; Content\; UoM =}$ $\boldsymbol{\sqrt{\frac{h.c^5}{G.(k_{B(J/K)})^2}} \times \ln(4)}$	6.4

= 4.9234x10^{32}

Equation (6.4) delivers an additional Boltzmann-based *Content Appearance* yardstick.

The *Crenel Physics* version of equation (6.4) is:

$\boldsymbol{1\,P = \sqrt{\frac{h_{CP}}{G_{CP}}} \times \frac{\ln\,(4)}{k_{B(\frac{energy}{temperature})}}}$	6.5

(Entropy-Atoms)

In this newly introduced *Appearance* of *Content*, applicable to the *verifiable* version thereof, we can continue to use Planck's constant *h* as is (i.e., apply it to both the verifiable *Entropy-Atoms* as well as to the unverifiable *Photons*), rather than correcting it for the *Entropy* value of *Entropy-Atoms* (which are the elementary building blocks for all *verifiable* matter).

In equation (6.5) we continued using the *energy/temperature* version of k_B. It is worth noting that in *Crenel Physics* there would be no difference between using, for example, the alternative *UoM's mass/temperature* or *frequency/temperature* for k_B. This will not be the case in other systems of *UoM* such as *Metric Physics*. The k_B version used here provides a basis for later verification of equation (6.5) within *Metric Physics*.

f) Frames of Reference

We need a *frame of reference* to specify the *where* and *when* of our observations/verifications.

Typically, we thereby use a '*mathematical frame*', i.e.: a frame based on mathematical rules. For example, a '3-dimensional *Cartesian frame*', enhanced with a fourth dimension for *time* specifications. In it, we envision straight and perpendicular gridlines at equal distance. And anywhere within, *time* evolves at a regular and constant pace. The coordinates of our observations -relative to this frame- then provide the *where* and *when* answers.

However, *mathematical* frames have flaws when it comes to their usage in *physics*.

This can be illustrated by reviewing the difference in the definition of a *distance* between two points.

(52) Per *Mathematics*, the *distance* between two points is the length of a straight line between those points.

Whereas:

(53) Per *Physics*, the *distance* between two points is the pathlength of the fastest route between those points.

The *physical* definition gives us the direction(s) for traveling within the shortest possible *time* from 'A' to 'B', regardless our *velocity*. Obviously, the lower our velocity, the longer it will take. But if we follow those direction(s), we will arrive within the shortest possible *time*, and thus followed the shortest possible path.

As we will address in the following, the usage of light thereby is a handy tool: we exactly know its velocity since per *Metric Physics* -for vacuum conditions- we defined it to equal exactly *299,792,458* $^m/_s$. In *Crenel Physics* we normalized its value to exactly 1.

Thus, from some location 'A' we may send a light flash in all directions. From some location 'B' it can be reflected. At 'A' we measure the *time* difference (in *seconds*) between departure and return, divide that by two (since the light made a round trip), and multiply it with the velocity of light *299,792,458* $^m/_s$. The outcome then is the *distance* in *meters*.

Given the exact value of light velocity, the accuracy of our *distance* measurement exclusively depends on the accuracy of our *time* measurement. And clocks are amongst the most accurate instruments that we can produce (if not the champion in accuracy).

In an empty space, light will physically follow a straight line. In such case there is no difference between the mathematical and physical paths.

However, Einstein found that -within a *mathematical* frame of reference- light/photons follow a curved path when passing a *gravity* field. Hence *Photons* do *physically* follow an *apparently* stretched/longer path relative to the mathematical straight line. The question then is whether we can still use the afore mentioned procedure for measuring a distance.

Consider the Earthly observation of a star hidden behind a black hole. Per the *mathematical* definition, within -for example- a Cartesian frame of reference our *distance* from that star equals the length of a straight line towards it. That line goes straight through the black hole.

As said, per Einstein the black holes gravitational field curves the path of passing light. In this example the light from the star behind the black hole will appear to arrive from another direction, deviating a (very) small angle $d\alpha$ from the *mathematically* shortest connection line. If then the observer, the black hole, and the star behind it are exactly lined out, there will be cylinder symmetry in $d\alpha$, so that the light of the star will physically come from a ring around the black hole, rightfully referred to as an 'Einstein ring'. Proof thereof was found in the actual observations thereof, as the following figure shows.

Fig. 6.1: Einstein ring
Credit: Wikipedia.

If then -hypothetically- we want to hit the star with a laser beam, we must aim the beam towards any point on the Einstein ring as seen. The laser light will then surely hit the star, as it will exactly follow the incoming light path in the opposite direction. However, there is an entire ring to aim at, so that our options are defined by a (very narrow) cone. Per the *physical* definition we thus have an infinite number of directions to aim at, thus of 'shortest' path options. Within a *Cartesian* frame of reference, these all are found slightly longer than the straight line towards the star.

The question then is: which of the two definitions delivers the true *distance* towards the star?

To find the answer we will perform another experiment. For this we ask an astronaut in deep space to cut a rope with an exact length of *10 meters*. The astronaut will use the *physical* method: he cuts it at a length for which it took light *10(s)/299,792,458(m/s)* travel time. Thus, this rope is indeed exactly 10 meters long. And since there is no gravity around him, that rope also has an exact length of *10 meters* within his *mathematical* frame of reference; there is no difference. Now, this same rope is transported to us on Earth.

Per *theory of relativity*, due to the Earth's gravitational field, when seen from deep space, *distances* on Earth appear stretched. To the remote astronaut the rope will therefore appear longer. However, from the remote perspective clocks on Earth also appear run at a proportionally lower pace.

The key here is that *distance* and *time* stretch proportionally, regardless strength of *gravity* (or magnitude of *acceleration*).

Thus, when we double check the rope's length on Earth, on our Earthly clock we will also find that it takes light *10(m)/299,792,458(m/s)* to travel along it. Hence, we confirm the *10 meters*. In short: the remotely 'seen' spatial stretching is only *apparent* and does not materialize locally. We can generalize this finding:

(54) Path stretching caused by *Gravity* is only *apparent*.

We can apply this finding to any *10 meters* section of the path that light followed while curving along the black hole: any *gravity* induced stretching is only *apparent*. For example, at the path section nearest to the black hole such section will only *appear* longer to us, but locally it will still measure *10 meters*. This finding applies to any section along the entire path. Therefore, both the *mathematical* as well as the *physical* definition of *distance* produce equal outcome in *meters*. But, other than mathematics, physics tells us in which direction to depart. And in this case that direction deviates (slightly) from the direction towards the actual location (per the *mathematical* coordinates) of the star.

Let's further discuss this fundamental stronghold for consistency within the broader context of the *Crenel Physics* model. With *distance* and *time* being exactly proportional in all cases, the ratio of their *UoM's* (in *Metric Physics* thus the ratio *m/s*) must be a universal natural constant, thus is **not subject to relativity**. This ratio *distance/time* represents the *UoM* for *velocity*. We may now, for example, specify a *velocity* to equal 10 (*digital*) *m/s* relative to some object. Per *Crenel Physics* model, the 10 (*digital*) of this specification is *Information*, and hence it is instantaneously universally equal. This, combined with the *UoM* (here *m/s*) also being equal to all, ensures that the *velocity* specification '10 (*digital*) *m/s*' in the example at hand is universally equal. It is not subject to (the theory of) relativity. The *velocity* of light '*c*' -relative to any observer, sensor, or object- is no exception. Einstein's conclusion that the *velocity* of light is equal to all can therefore be enhanced:

(55) Any *velocity* -relative to some object- is equal to all.

What remains after the above elaboration is, that per *mathematics* there can only be one exclusive solution for the shortest path between two points, whereas per *physics* there might be an infinite number of shortest paths, as the Einstein ring demonstrates.

To *mathematically* construct a frame of reference that covers the *physical* facts (as nature truly provides) may demand that the mathematical one-dimensional line within a *Cartesian* frame of reference is to be replaced by -as per our example- a cone. Our human brains are not equipped to envision that. At most we can model it by extrapolations of mathematical rules.

The above also tells us something about Newton's laws, in which the *gravitational* force depends on *distance* from the mass involved. The presence of the black hole in our example curved the shortest path towards the star, but this did not impact the *length* thereof, i.e., the distance. Per Newton's gravitational equation the presence of the black hole therefore did not impact the gravitational force between Earth and star. We generalize this:

(56) The *gravitational* force between two objects is not impacted by the presence of 'third party' *gravitational* fields.

Of course, the total gravitational force as experienced by an object is a summation of all one-to-one forces.

(7) The Gravitational Constant *G*

We found that *Photons*, *Mono-Bits* and *Entropy-Atoms* have different properties when it comes to remote *observing* and *verifying*:

- ✓ *Photons* -during their lifetime- cannot be remotely found in some state. They shape a separate league.
- ✓ *Mono-Bits* are hypothetical objects. In concept these could be remotely observed, but their existence cannot be verified.
- ✓ *Entropy-Atoms* are the elementary building blocks for the *verifiable*.

a) Entropy-Atoms and Gravity

In Chapter 1 (equations (1.15) and (1.16)), we found the *Package* yardstick for both the *energy* and *mass Appearances* to equal:

$$1\ P = \sqrt{\frac{h_{cp}}{G_{cp}}}$$

This equation came forth from applying Planck's equation $E = h.\upsilon$. Later we found that Planck's equation is restricted to objects with an *Entropy* value of 1 *nat*, that is *Photons*. And when integrating Boltzmann's equation $S = k_B.ln\ (w)$ into the *Crenel Physics* model, we derived the 'enhanced Planck equation' (4.24):

$E = h.\upsilon.S_{(nat)}$

This equation can be applied to objects with an *Entropy* value greater than or equal to 1 *nat*.

Chapter 6 defined *Entropy-Atoms* as the elementary building blocks for *verifiable* objects. Per equation (6.5), we found the associated yardstick for their *Content Appearance* to equal:

$$1\ P = \sqrt{\frac{h_{CP}}{G_{CP}}} \times \frac{\ln(4)}{k_{B(\frac{energy}{temperature})}}$$

Thus, the *Crenel Physics* model produced two apparently different yardsticks for *Content*: one for the <u>un</u>*observable*/<u>un</u>*verifiable* (*Photons*) and one for the *verifiable* (*Entropy-Atoms*). The root cause was our objective to use one single Planck constant for both scenarios. So how do we deal with having two apparently different yardsticks?

We must demand that between a *Photon* and an *Entropy-Atom* the *Content* yardstick is equal. If not, *Packages* could appear or disappear when *Photons* are generated or absorbed, which would conflict with the conservation principles.

The factor $\frac{\ln(4)}{k_{B(\frac{energy}{temperature})}}$ in equation (6.5) is however not equal to dimensionless '1'. Therefore, at first sight we seem to have an inconsistency.

Such is not the case if a universal relationship exists between the embedded natural constants h_{CP}, G_{CP} and k_B. In fact, based on the validity of the equations (1.15/CP 1.16) and (6.5) we must insist on this relationship.

It can be found by multiplying the two *Content* yardsticks. Each yardstick must equal *1 P(ackage)*. The multiplication of these two *Content* yardsticks then must equal *1 P(ackage)*^{2}:

$\left\{\sqrt{\frac{\boldsymbol{h_{cp}}}{\boldsymbol{G_{cp}}}} \times \frac{\mathbf{ln\ (4)}}{\boldsymbol{k_B}(^{\boldsymbol{J}}/_{\boldsymbol{K}})}\right\} \times \left\{\sqrt{\frac{\boldsymbol{h_{cp}}}{\boldsymbol{G_{cp}}}}\right\} \equiv \mathbf{1}\ (\boldsymbol{Package^2})$	7.1

This requirement can be rewritten as:

$$G_{CP} = \frac{h_{CP}}{k_B(^J/_K)} \times ln\ (4) \times\ Package^{-2}$$

Note that the *UoM Package*$^{-2}$ is equal to *Crenel/Package*, so that the *UoM* for G_{CP} is consistent with equation (1.2):

$\boldsymbol{G_{CP}} = \frac{\boldsymbol{h_{CP}}}{\boldsymbol{k_B}(^{\boldsymbol{J}}/_{\boldsymbol{K}})} \times \boldsymbol{ln\ (4)} \times \frac{\boldsymbol{Crenel}}{\boldsymbol{Package}}$	7.2

(between Entropy-Atoms)

Equation (7.2) is fundamental. It shows that the gravitational constant G_{CP} is **not** an independent universal natural constant: its value can be calculated.

Because all *verifiable* objects are constructed of *Entropy-Atoms*, equation (7.2) must hold for the *verifiable*. Furthermore, it must hold within any system of *UoM's*. We will confirm this within *Metric Physics* later in this chapter.

b) Mono-Bits and Gravity

There are no focussed experiments that demonstrate the existence of *Mono-Bits*.

The hypothetical possibility that *Mono-Bits* exist leaves room for some remote interaction mechanism, for example, between them. Such an interaction would induce *Content* and thereby induce *Gravity*.

Between two remote *Mono-Bits* the gravitational constant would equal:

$\boldsymbol{G_{CP} = \frac{h_{CP}}{k_B} \times ln(2) \times Package^{-2}}$	7.3

(between 1-bit objects)

The term *ln(2)* in this equation represents the *Mono-Bit's Entropy* value of 1 *bit*, expressed in *nat*.

Because *ln(2)/ln(4)* = 0.5, the value of the gravitational constant between two *Mono-Bits* thus would equal half the gravitational constant as found between *Entropy-Atoms (7.2)*.

Mono-Bits may explain 'dark matter', causing gravitational forces within the universe to exceed the value that can be explained by the *verifiable*.

Per the *Crenel Physics* model, *Mono-Bits* would be *observable* if -by remote interaction- they generate a gravitational force. But they would not be *verifiable* as individual particles. We could neither reconcile where they were in the past, nor predict where they will be in the future. Yet their *Gravity* would reveal where they are now.

Mono-Bits might replace the hypothetical WIMPS (Weakly Interacting Massive Particles), with the difference that *Mono-Bits* -when left alone in empty space- are not massive.

c) Higher Bit Objects and Gravity

Per the *Crenel Physics* model, 3-*bit* objects would be *observable* and *verifiable* as isolated objects.

In Chapter 12, we will argue why 2-*bit* objects are nature's default. Chances for the existence of isolated 3-*bit* or higher *bit* objects are highly unlikely.

d) Levels of Ensemble

The most basic *verifiable* particle in the *Crenel Physics* model, the *Entropy-Atom,* is **the** universal elementary building block of any *verifiable* object to which we can apply the (verifiable) laws of physics.

This is reflected by re-writing Newton's gravitational equation as:

$$F_{gCP}\left(in\,{}^{P}\!/_{C}\right) = G_{CP}\frac{Content(1) \times Content(2)}{d^2}$$
$$= \frac{Crenel}{Package}\frac{Content(1) \times Content(2)}{d^2}$$

Based on the *principle of equivalence*, in this equation, the *Content* of an object consisting of an ensemble of '*n' Entropy-Atoms* needs enhancement:

$\boldsymbol{Content} = \sum_1^n [\boldsymbol{T_{embedded}} \times \mathbf{ln(4)}]$ $-(\boldsymbol{binding\ energy})$ $+(\boldsymbol{heat})$ $+(\boldsymbol{field\ energy})$ $+(\boldsymbol{kinetic\ energy})$	7.4

The correction factors '*binding energy*' and '*heat*' as introduced in equation (7.4) were addressed when discussing Einstein's *principle of equivalence* (Chapter 1).

We saw that an iron atom weighs 1% less than the summation of its constituents. The difference is explained by the '*binding energy*' that was released when the constituents of the atom joined the atom's structure.

The term '*heat*' in equation (7.4) expresses that an aggregation of particles can be found in more states than presumed by Boltzmann's model. The latter presumes that when we combine two objects A and B, the *Entropy* (in *nat*) equals the summation of both respective *entropies*. However, if for example A and B are two atoms found within a brick, those atoms may vibrate at some *frequency* relative to one another, causing additional (Planck based) *Content* in the macroscopic shape of *heat*. The term '*heat*' in the above equation represents such potential impacts on *Content*.

Finally, the terms '*field energy*' and '*kinetic energy*' were added. The term '*field energy*' addresses, for example, that potential gravitational *energy* (largest at infinite *distance* from *Content* embedding objects such as the Earth) is converted into *Content* as it diminishes. That is, a brick on Earth appears to embed more *Content* than that same brick in deep space. When falling, such absorbed '*field energy*' will initially appear as kinetic *energy* (both equally added to the Earth as well as to the brick). This *Appearance* can be converted into *Content* by slowing the object down. This is consistent with the earlier remark that *Acceleration*, being expressed in *Crenel*$^{-1}$, thus in *Packages*, is an *Appearance* of *Content*. Initially that *Content* gain might have the *Appearance* of *Acceleration.* Per the *Crenel Physics* model, this can be converted into the *mass Appearance* at a 1:1 ratio.

Within mainstream physics, the most elementary particles we are currently aware of are defined by the 'standard model'. Based on their distinguishing individual properties these can be differentiated relative to one another (e.g., quarks versus electrons). Consequently, these particles are (much) more complex than *Entropy-Atoms* which have only two properties: their *Entropy* (of 2 *bits*) and internal *frequency*.

The *Crenel Physics* model suggests that low level ensembles of *Entropy-Atoms* can jointly produce a variety of properties that show some level of stability. We thus envision quarks and other elementary particles within the 'standard model' as various types of ensembles of *Entropy-Atoms*.

It is at this elementary level where we must expect Einstein's '*principle of equivalence*' to start kicking in. We must expect some binding mechanism that prevents a particle like a quark or an *electron* from falling apart. A source of binding *energy* between *Entropy-Atoms* may be found in natures drive towards symmetry. Future computer simulations might reveal a pallet of potential *Entropy-Atom* ensemble structures at various levels of stability. The *Entropy-Atom* model, as introduced in Chapter 12, may serve as a starting point.

A higher level comes into play when elementary particles within the 'standard model' aggregate into, for example protons or neutrons.

Through nuclear binding energy we get atoms. Atoms in turn shape molecules and so on. All these levels contribute to the correction factor '*binding energy*'.

e) Verifying G

Let us evaluate how well the gravitational constant '*G*', as calculated per equation (7.2)…

$$G_{CP} = \frac{h_{CP}}{k_B(J/K)} \times ln\ (4) \times \frac{Crenel}{Package}$$

… fits the value for '*G*' as found in *Metric Physics*. As discussed, this value only holds at the lowest level within the *Crenel Physics* model (i.e., between individual *Entropy-Atoms)*.

For numerical verification in *Metric Physics UoM's*, we rewrite the equation as:

$$\boldsymbol{G = \frac{h}{k_B(J/K)} \times ln\ (4)} \qquad (7.5)$$

Note: The Crenel Physics model demonstrates that the apparent dimensional incorrectness in this equation indeed only is apparent. At the bottom line, the equation comes forth from the finding that Content equals inverted Whereabouts. This dimensional relationship is not reflected within Metric Physics.

When we substitute the *Metric Physics* values for *h* and k_B (in *J/K*), we find for the gravitational constant:

$$G = \frac{6.62606957 \times 10^{-34}}{1.3806488 \times 10^{-23}} \times 1.38629436111989$$

or:

$$G = 6.65316399 \times 10^{-11}$$

This numerical value is approximately 0.3% below the literature value of G=6.67384 x 10^{-11}.

Actual measurements of the gravitational constant are not only difficult to execute, but also prove to be mutually exclusive.

In Reference [2], an 'Improved Cold Atom' Measurement by Rosi et al. (published in 2014), *G* is reported to equal 6.67191(99) x 10^{-11} Nm^2kg^{-2}. This is approximately 0.03% below the commonly accepted value of 6.67384 x 10^{-11}.

Per the *Crenel Physics* model, a measurement of *Gravity* at low *temperature*s between relatively basic objects such as atoms should indeed result in a lower value of *G*, relative to a measurement between macroscopic objects (ensembles of atoms). The result found by Rosi et al. is therefore directionally consistent with the *Crenel Physics* model, even though Rosi et al. found only 10% of the difference that we are looking for (0.03% versus 0.3%). This suggests that about 90% of the impact of the *principle of equivalence* is to be found at the sub-atomic level.

(8) The Cause of Gravity

We found that *Planck objects* such as *Photons* are a special league, based on their Entropy value of 1 *nat*. How does this match actual observations? Let's first review some experimental data and explain how these fit within the *Crenel Physics* model. This will reveal the cause of *Gravity*.

Consider an experiment in which a *Photon* travels from deep space towards the Earth's surface. The *Photon* will then gain *energy*:

✓ First, because it is subject to the Earth's gravitational pull. Since its *velocity* is constant, the absorbed *potential energy* materializes as a *frequency* gain.
We will refer to this as the Newtonian '*potential energy gain*', in essence based on Newtons laws.

✓ Second, because as the Earth is approached, the local clock pace will slow down. Thus, per *time UoM*, locally a higher number of *Photon* oscillations will be counted, i.e.: a higher *frequency* will be found.
We will refer to this as the relativistic '*clock energy gain*', which is based on Einstein's *Theory of Relativity*.

We will review both impacts from the perspective of the *Crenel Physics* model. Here, *Whereabouts* and *Content* are related to each other: *Content* equals inverted *Whereabouts*.

The Earth is *Content*. We interpret it as inverted *Whereabouts*. Thus, *Content* can only be created at the cost of *Whereabouts*. Where *Content* is around, the conservation principle demands some compensating *Whereabouts* deficit (relative to the *Whereabouts* in empty outer space).

We can envision this deficit by imagining *Whereabouts* gridlines widening near *Content*. When we are observing from deep space, near *Content* all *distances* then appear stretched and clocks (i.e.: *time*) appear to run slower relative to ours.

This is a 3-dimensional way of representing Einstein's 'curving of space', which suggests a one-dimensional line that is 'curved'.

(57) We will refer to the regional widening of gridlines (*time* and *distances* alike) as a 'depression' in *Whereabouts.*

We can now model the cause of the gravitational force by envisioning that *Content* tends to move from 'high pressure' *Whereabouts* regions towards depression regions.

(58) *Whereabouts* is not only a frame in which we can specify coordinates (defining the *where* and the *when*), but it also embeds a local *Whereabouts* 'pressure' value that depends on the vicinity of *Content.*

The *Whereabouts* pressure is highest in empty outer space. We can normalize the 'pressure' value in outer space by envisioning that there the *Whereabouts* gridlines are 1 *Crenel* apart. And as seen from a remote position, these gridlines then appear to widen near *Content*. Thereby, 1 *Package* equals 1 inverted *Whereabouts* (= 1/*Crenel* = *Crenel*$^{-1}$), as discussed in chapter 3.

And as air moves from high pressure regions to low pressure regions, wherein the ***gradient*** in air pressure is the driving force, *Content* is likewise subject to a pulling force which is proportional to the (local) *gradient* in *Whereabouts* pressure. And this pulling force is named *Gravity*.

(59) *Gravity* is a pulling force acting on *Content*, which force is caused by -and proportional to- the local *gradient* in *Whereabouts pressure*.

The *gradient* of *Crenel*$^{-1}$ (the alternative measure for *Content*) equals –*Crenel*$^{-2}$. From this we conclude that:

(60) *Gravity* is proportional to -*Crenel*$^{-2}$, thus is proportional to -*distance*$^{-2}$.

Within the *Whereabouts* arena, the *Whereabouts* pressure is a scalar. Its *gradient* is a vector, which gives direction to the gravitational force. This -obviously- is fully consistent with Newton's gravitational equation.

Within the *Crenel Physics* model, it is easy to compare the magnitude of the afore mentioned '*potential energy gain*' with the '*clock energy gain*' of a descending *Photon*.

The '*potential energy gain*' equals the gravitational force, multiplied with the distance along which that force was applied. To find it, we need to **integrate** this force over the distance travelled. Since we **differentiated** the *Crenel*$^{-1}$ in the first place (to find the gradient, and thus the force), this integration of the differential obviously re-produces the original result: *Crenel*$^{-1}$.

Within the normalized *Crenel Physics* system of UoM's, this *Crenel*$^{-1}$ also equals the slow-down factor of the local clock, relative to the clock in deep space, i.e.: the afore mentioned relativistic '*clock energy gain*'.

We therefore conclude that both energy gains are equal. This equality -as demonstrated within the *Crenel Physic* model- must then obviously hold within any system of *UoM's*:

(61) The *energy* gain of a descending *photon* in a *gravitational* field consists of two equal components: the (Newtonian) '*potential energy gain*' and the (relativistic) '*clock energy gain*'.

a) Experimental verification.

Per *Crenel Physics* model, the **gradient** in *distance/time* stretching (dilatation) is the cause of *Gravity*. Since we need the **gradient,** and not just the value of this stretching, we need solid experimental proof that the *Theory of Relativity* is accurate.

With today's very precise clocks, the *time* stretching caused by *Gravity* -per *Theory of Relativity*- has been verified in numerous ways.

For example, without taking it into account, the current GPS navigation systems would embed major errors. A GPS satellite clock runs faster than a clock on the ground by about 38 microseconds per day. The GPS system is completely based on *time* measurements: all *distances* are **calculated** per *physical* procedure (see Chapter 6).

There is a major advantage of using *Photons* in experimental verification: we do not have to measure their *velocity* since it is a constant. We only need to measure their *frequency* shifts to determine *energy* shifts (Newtonian or relativistic alike).

The first 'classical' test that *Photons* indeed gain/loose energy when descending/ascending a gravitational field was performed by Pound-Rebka in 1959 (see Reference [7]). These measurements confirmed the *Theory of Relativity*: the impact -in both directions- was found equal, and consistent with the theory. It was measured with an accuracy of 10%. The experiment initiated additional tests. Later tests reached an accuracy of 0.01%.

As said, per *Crenel Physics* model, *Gravity* is caused by -and proportional to- the local *gradient* in *Whereabouts pressure*. This gradient is represented by -or can be envisioned as- the local widening of *Whereabouts* gridlines. But how does *Content* widen these?

In the next chapter we will analyse orbiting. As it turns out, orbiting fully fits and explains the *Crenel Physics* modelling of *Gravity*.

(9) Orbiting

Orbiting is associated with a *frequency* which in turn, per enhanced Planck's equation…

$E = h.\upsilon.S_{(nat)}$

…is associated with *Content*.

a) Converting Forward Motion into Orbiting

Consider an object 'A' that is moving forward in an otherwise empty space. At some point the object is suddenly attached to the end of a straight rope. The other end of the rope is tightly connected to some fixed point 'X' in space. This forces 'A' into a circular orbit:

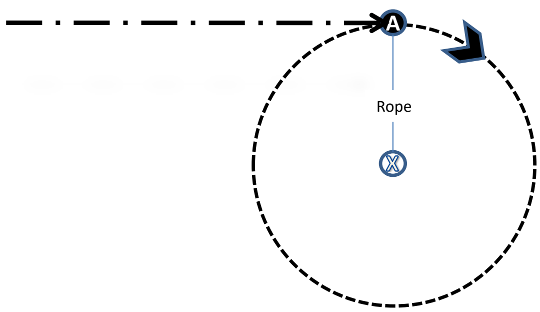

Fig. 9.1: Object 'A' is forced into a Circular Orbit

As this happens, the forward *velocity* of 'A' will remain unchanged because there is no force in the forward or backward direction relative to the direction of the *velocity*. However, the imposed orbiting causes an orbiting *frequency* 'υ' which did not exist before. Per enhanced Planck's equation $E = h.\upsilon.S_{(nat)}$, this is to be associated with a gain in *Content*. We will refer to this gain as 'Planck based *Content*':

(62) 'Planck based *Content*' is *Content* that comes forth from the enhanced Planck equation $\boldsymbol{E = h.\nu.S_{(nat)}}$.

Where did that extra *Content* come from? How does it reveal itself? How is the conservation principle obeyed?

To answer these questions let us further analyse orbiting and its impact on *Whereabouts* gridlines.

b) Gravitational Orbiting of Two Objects

Consider two equal point objects 'A' and 'B', keeping each other in a gravitational orbit around their centre of *Gravity* 'X'. We position ourselves at some remote point on the axis of the orbit path. This is what we see:

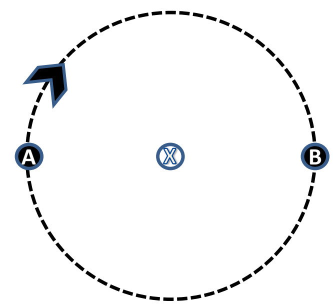

Fig. 9.2: Two equal Objects 'A' and 'B' orbiting around their Centre of *Gravity* 'X'

It takes light some *time* to travel from the objects towards us. Therefore, our observations are delayed in *time*. Since we reside on the orbit axis, the *distance* from objects 'A' and 'B' towards us is equal and constant. This causes our visual observations of objects 'A' and 'B' to be equally delayed, so that we can ignore this *time* delay while reviewing the dynamics of the system.

As figure (9.2) shows, at any moment in *time* we see objects 'A' and 'B' at opposite positions on their shared orbiting path. At first sight, this might sound like a simple Newtonian observation. But there is a deeper fundamental insight underneath.

To surface it, we will measure the *distance* between object 'A' and object 'B'.

As discussed, for that we use a local clock (a clock we hold in our hand) and the *velocity* of *Photons* (*velocity c)* which is universally equal. The *time* Δt_{local} needed for light to travel a *distance*, when multiplied with the *velocity c*, unambiguously delivers the length of that *distance*:

$\boldsymbol{Distance_{Local} = \Delta t_{local}.c}$	9.1

With regards to our *time* measurement (Δt_{local}), if we hold a clock in our hands, we will never see that clock run faster or slower, regardless of our circumstances. The reason being that we and our clock share the same circumstances; there are no relative differences between us and our clock. The *Theory of Relativity* says that only remote clocks may run faster or slower relative to our local clock. Hence, we used the subscript 'local' in Δt_{local}.

With the above in mind, we ask a helper residing on object ‘A’ to measure the *distance* to object ‘B’. We will name their result ‘*LOD*’ (the Locally Observed *Distance*). At first sight this should be an easy task since that helper sees that their *distance* towards object ‘B’ is constant in *time*. They aim a laser apparatus towards object ‘B’ and send a flash of light. They use their local clock to measure how long it takes before they receive the reflected flash. Because this light flash made a round trip, they will cut that *time* in half, name the result Δt_{local}, and multiply that with light *velocity c* to find the *distance*. Thus:

$\boldsymbol{LOD = \Delta t_{local}.c}$	9.2

However, the aiming of the laser to hit ‘B’ is somewhat complicated. Should they aim toward the location where they see it? In doing so, they would overlook two issues:

1. Due to its orbiting, object ‘B’ is not anymore where they see it.

   For example, the Moon is not where we see it. We see the Moon where it resided about 1.3 seconds ago (since the distance between Earth and Moon is about 400,000 km, and the velocity of light is about 300,000 km/s). During those 1.3 seconds the Moon has progressed in its orbit.

2. Although they could calculate the actual position of object ‘B’, aiming their laser at that point would not work either.
   By the *time* the laser flash reaches that point, object ‘B’ will again have moved forward on its orbit path.

We can review the challenge from the perspective of our remote observation location on the orbit’s axis. To avoid any potential confusion, we define the ‘*ROD*’ as the Remotely Observed *Distance* between objects ‘A’ and ‘B’. The *ROD* is the *distance* as **we** see it; that is, the diameter of the orbit as shown in figure (9.2).

The following figure illustrates the challenge:

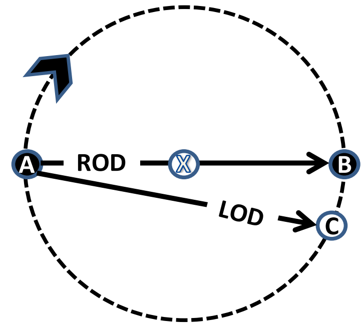

Fig. 9.3: The Remotely Observed *Distance* ‘*ROD*’ and the Locally Observed *Distance* ‘*LOD*’

It shows a location ‘C’. This is the anticipated location where object ‘B’ (from our remote perspective) will reside by the *time* a light flash from location ‘A’ will arrive at object ‘B’.

The line ‘*LOD*’ therefore represents the direction as well as the path that the *Photons* in the laser flash will physically follow from the perspective of our remote observation point.

Our helper on object ‘A’ needs no understanding of the afore mentioned complications. After wondering why their laser misses the target all the *time*, they replace it with a light bulb, simply sending a light flash into all directions. Hitting object ‘B’ is then guaranteed. So now they can measure the *LOD* per equation (9.2).

As the figure (9.3) shows, location ‘C’ is closer to location ‘A’, or:

$\boldsymbol{LOD < ROD}$	9.3

We therefore conclude that:

(63) When seen from a remote position, the *distance* between two orbiting objects (the *ROD*) appears stretched relative to the local *distance* (the *LOD*).

To quantify this stretching, we must pinpoint ‘C’ in figure (9.3). For that we will forward-track object ‘B’ on its orbiting path. Thus, ‘C’ is the location where we will see ‘B’ after Δt_{remote} seconds. To ensure a hit with a narrow laser beam, we calculate the value of Δt_{remote} as the *time* it takes light (on our clock) to travel the *distance* between ‘A’ and

'B' as **we** see this *distance* (i.e.: the diameter of the orbit per figure (9.3)):

$\boldsymbol{\Delta t_{remote} = ROD/c}$	9.4

Given some yet unknown orbit *velocity* 'v_{orbit}', we can now reckon the length of the forward-track orbit section 'BC':

$\mathbf{BC} = \mathbf{v}_{orbit}.\boldsymbol{\Delta t_{remote}} = \mathbf{v}_{orbit}.\boldsymbol{ROD/c}$	9.5

The higher the orbit *velocity* 'v_{orbit}', the further we must forward-track point 'C', and as figure (9.3) illustrates, the shorter the resulting *LOD*.

There is a hard constraint, as 'v_{orbit}' cannot exceed light *velocity* '*c*'. Ultimately, the length of the forward-track path '$v_{orbit}.ROD/c$' would be at its maximum:

$\boldsymbol{c.\frac{ROD}{c} = ROD}$	9.6

The following figure shows this scenario:

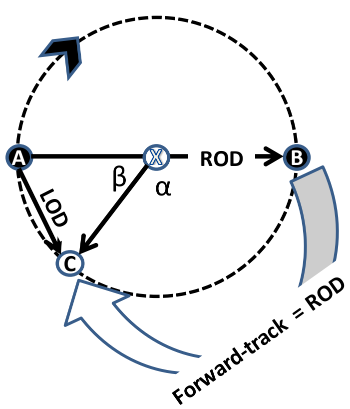

Fig. 9.4: The Location of 'C' at the maximum Orbit *velocity*, whereby $v_{orbit} = c$

This gives a fixed and well-defined minimum value for the ratio *LOD/ROD*. It is found as follows:

The angle marked 'α' equals:

$$\left(\frac{ROD}{\pi.ROD}\right) \times 2.\pi = 2\ radials$$

Note that this is a maximum value for 'α' which applies to **any** orbit diameter, for as long as the orbit *velocity* equals *c*.

The angle marked 'β' in figure (9.4) then equals $(\pi - 2)$ *radials*.

The sinus of half the angle β= $\left(\frac{\pi-2}{2}\right)$ *radials* is equal to half of the '*LOD*', divided by half the '*ROD*'. The minimum ratio *LOD/ROD* is then calculated as:

$$\frac{LOD/2}{ROD/2} = \frac{LOD}{ROD} = \sin\left(\frac{\pi-2}{2}\right) = \cos(1) = 0.5403\ldots$$

Thus, should both objects orbit at light *velocity* '*c*', we find for any orbit diameter:

$\boldsymbol{LOD = ROD \times \cos(1)}$	9.7

Figure (9.5) is used to find this ratio for any lower v_{orbit} :

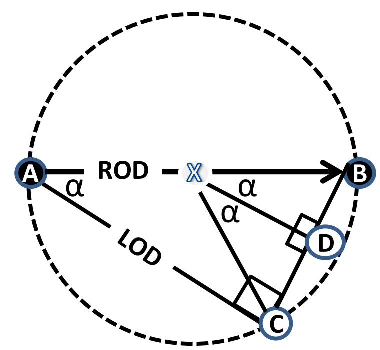

Fig. 9.5: *LOD/ROD* for lower Orbit Velocities

Within this figure there are two goniometric properties that are helpful:

1. For any point 'C' on the circular orbit path, and thus for any orbit *velocity* v_{orbit}, the angle ACB equals 90^0 as indicated.
2. All three angles marked 'α' are equal.

Angle BXC (2.α) equals:

$$2.\alpha = \frac{v_{orbit}.ROD/c}{\pi.ROD} \times 2.\pi\ (radials)$$
$$= \frac{2.v_{orbit}}{c}\ (radials)$$

Angle BAC is half of that and thus equals: $\frac{v_{orbit}}{c}$ radials.

From figure (9.5) it can be seen that *cos(α) = LOD/ROD*. Therefore:

$$\frac{LOD}{ROD} = \cos\left(\frac{v_{orbit}}{c}\right) = \sqrt{1 - \left(\sin\left(\frac{v_{orbit}}{c}\right)\right)^2} \quad (9.8)$$

Or:

$$ROD = LOD \times \frac{1}{\sqrt{1 - \left(\sin\left(\frac{v_{orbit}}{c}\right)\right)^2}} \quad (9.9)$$

Equation (9.9) quantifies how, when seen from a remote observation point, an orbiting system appears spatially stretched.

Equation (9.9) thus defines the magnification factor of some imaginary magnification glass through which we remotely 'see' the orbiting system. Thereby we implicitly 'see' the widening of *Whereabouts* gridlines at the orbiting system.

Having to deal with different values for *ROD* and *LOD*, the question arises: what is the 'real' *distance* between objects 'A' and 'B'?

To find the answer, our helper at object 'A' picks up their phone to tell us that they measured the *LOD* to equal say, 20 meters. They ask us to deliver a measuring tape of exactly this length, so that they can verify this. At our remote location we therefore cut a 20-meter length of tape while residing within our frame of reference. For that, we use our own (remote) clock and our own light source to ensure that the tape is exactly 20 meters long. We now send it to our helper on 'A'. As we already found, the person who transports it will, while underway, never see a change of length of carried objects. To them the tape always remains 20 meters in length. Therefore, when they deliver it on 'A' it will still be found to have a length of 20 meters, which matches the *LOD* as specified. The 20-meter tape that we cut and sent, meets the demanded length, and therefore will be found to exactly match the *distance* between 'A' and 'B'. This is the same *distance* is as we remotely see it: we see the *ROD*.

Therefore, when asked what the 'real' *distance* between objects 'A' and 'B' is, both local and remote observer will come up with the same answer: 20 meters. It is the local *Whereabouts Depression* that makes this *distance* only to **appear** stretched to us at our remote position. In fact, it is not. The underlying reason is that, when seen from our remote perspective, not only *distances* appear stretched, but *time* measurements at the local site will appear proportionally stretched (thus clocks will run proportionally slower) when compared to our remote position.

In terms of *Crenel Physics*, from a remote perspective there only **appears** to be an orbiting induced *Whereabouts Depression*. As both local and remote observer found, the *Information* part of the specification (the 20) matches. It is the *meter* (the applied *Whereabouts UoM* for *distance*) that appears differently. This is consistent with our earlier finding (Chapter 4) that the *Information* of the specification is 'available' and equal between all observers.

c) Low Orbit Velocities

For orbit velocities that are low relative to light *velocity* '*c*', equation (9.8) can be approximated by:

$$ROD \approx LOD \times \frac{1}{\sqrt{1 - \frac{v_{orbit}^2}{c^2}}} \quad (9.10)$$

$$(for\ v_{orbit} \ll c)$$

Equation (9.10) approximates (for example) the *space/time* magnification/stretching factor for remotely observed planetary orbiting systems. Here, orbit velocities are low relative to light *velocity*. In this equation we recognize the equation for Lorentz contraction which applies to objects that move relative to the observer. However, in the case of orbiting systems where the centre of *Gravity* does not move relative to us, we remotely see an orbiting induced **expansion**, not a **contraction**.

d) Reverse Engineering

Per equation (9.9), from our remote position we reckon a shorter local orbit path length (= π.*LOD*) relative to the longer *meter* and longer associated orbit path that we remotely observe (= π.*ROD*).

In the above modelling, we embedded that the centre of *Gravity* 'X' of the orbiting system is not moving relative to us. Therefore, per enhanced Planck's equation $E = h.\upsilon.S_{(nat)}$ we must demand that the *Content* that is associated with the orbiting is found equal between the local and the remote observer.

If then (as found) the orbit path length appears stretched from a remote perspective, we must insist on an equal remotely observed stretching of the *time* measurement applicable to the orbiting system. This ensures that both observers indeed come up with the same orbiting *frequency* and thus will come up with the same Planck induced *Content*. In short, when seen from a remote perspective, *time* measurements at the orbiting system **must** appear proportionally stretched; proportional to *distance*.

In Chapter 1 we found this proportional relationship between the *Whereabouts Appearances distance* and *time* to be a consequence of our choice to normalize light *velocity c* to the dimensionless numerical value 1. This choice came forth from (arbitrarily) starting our considerations with Einstein's equation $E = m.c^2$.

But based on the above we can now 'reverse engineer' this initial choice. The above analyses of orbiting systems are a decisive physical argument to insist on this proportional relationship between *distance* stretching and *time* stretching.

Earlier we referred to this proportionality as '*the Enhanced Principle of Equivalence*' that applies to all *Appearances* in the *Whereabouts* arena.

Because *distance* and *time* are found to stretch proportionally, their respective *UoM's* stretch proportionally, not the numerical values (thus *Information* part) thereof.

Thus, we demonstrated that the ratio *distance* over *time UoM* must be a universal physical constant. This ratio defines the universally constant *velocity* of light '*c*'.

Any *velocity* can be specified as a fraction thereof. Thus:

(64) *Velocity* is universally equal.

Consequently, *velocity* is not subject to the *Theory of Relativity*, whereas its numerator *distance* and denominator *time* are.

To complete the 'reverse engineering' (relative to Chapter 1), with our finding that '*c*' is dimensionless, it then is a consequence (and not an option) that *mass* and *energy* per Einstein's equation $E = m.c^2$ must be of equal dimension. In essence, nature gave us no choice in 'what candy to pick'. In Chapter 1 we picked the right one indeed.

e) Stable Orbits

Per our remote observation, we found that *Photons* traveling from object 'A' to object 'B' physically followed the line *LOD* as shown in figure (9.3). Let us enhance the experiment by reflecting the incoming *Photons* that arrive at object 'B' back to object 'A'.

Upon return, object 'A' will have progressed to location 'D' as indicated in the following figure:

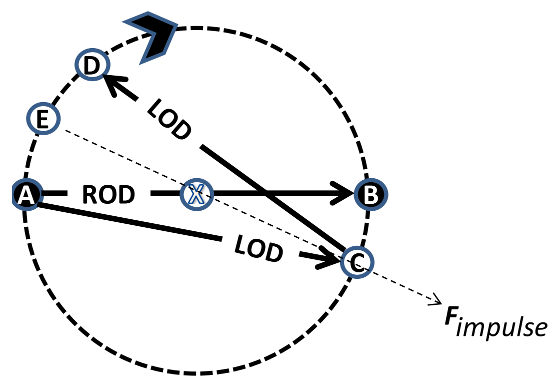

Fig. 9.6: 'C' mirrors Light back to 'D'

Thereby, the length of orbit path section 'AED' is exactly twice 'BC'. Again, we reckon that the path of the reflected light was of the length *LOD*. This confirms that the procedure to measure the *distance,* as followed by our helper on 'A', was correct by dividing the roundtrip *time* of their light flash by 2. The light to and from object 'B' followed equal pathlengths.

The symmetry in figure (9.6) also shows that the impulse force '$F_{impulse}$' caused by the reflected *Photons* at 'C' is directed away from point 'E'. At all times, the *Photon* impulse force therefore is directed away from the exact opposite orbit location as we remotely see it.

In comparison, the gravitational force (though attracting and not repelling) between both orbiting objects has likewise dynamics. The gravitational force points toward the exact opposite orbit location as we remotely see it. This explains why circular gravitational orbits can be stable, meeting Newtonian equations.

(10) The Gravitational Force

The *gradient* in *Whereabouts pressure* is the cause of the gravitational force (Chapter 8).

From a remote perspective, orbiting systems appear stretched per equation (9.8):

$$\frac{ROD}{LOD} = \frac{1}{\cos\left(\frac{V_{orbit}}{c}\right)}$$

Based on the above, we have a second means (Chapter 7) to quantify the strength of the gravitational force.

Prior to doing the math, we will review the *Crenel Physics* model for as far as it is relevant to the task at hand.

a) *Crenel Physics (Summary)*

When traveling from our remote position towards an orbiting system, according to some yet unknown curve, we expect the *Whereabouts pressure* around us to go down. The (local) steepness of this curve quantifies the (local) *gradient* in *Whereabouts pressure*, which in turn is proportional to the (local) strength of the gravitational force.

We will start the math by exploring the (imaginary) *Whereabouts* gridline between us (residing at our remote location) and some chosen point on the path of an orbiting system. How is this gridline curving within a Cartesian frame of reference? With the answer to this question, we can find the *gradient*.

Thereby, the path of *Photons* is our guide. *Photons* follow the shortest path from a physical perspective, where these may curve within a Cartesian frame.

b) *A Photon's Path Curving*

We use figure (9.2) as repeated below:

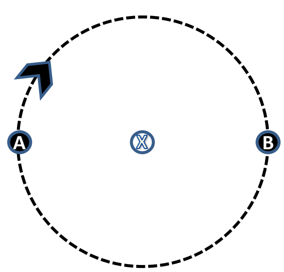

Fig.10.1: Equal Objects 'A' and 'B' orbiting around their shared Centre of *Gravity* 'X'

Consider the path of a single *Photon* that was emitted by object 'A', and thereafter travelled towards us while we reside at some remote location somewhere on the orbit axis.

To us, the *Photon* appears to come from some point on the orbit path as **we** see it; that is, coming from some point on an orbit with the previously defined diameter *ROD* (the Remotely Observed *Distance* between 'A' and 'B').

We found that from our remote perspective, we see orbiting systems enlarged per equation (9.8):

$$\frac{ROD}{LOD} = \frac{1}{\cos\left(\frac{V_{orbit}}{c}\right)}$$

Although we see the *Photon* coming from an orbit with diameter *ROD*, we would reckon that (within our Cartesian frame of reference) locally it was emitted from an orbit with the shorter diameter *LOD*.

The difference between *ROD* and *LOD* tells us how the *Photon* changed direction within our '*Cartesian frame*' of reference. We will name the angle of the course change $d\alpha$.

Angle $d\alpha$ thus equals the **total** curving of the imaginary *Whereabouts* gridline within our '*Cartesian frame*'.

c) *Quantifying the Gridline Curving*

The following figure shows the total course change $d\alpha$:

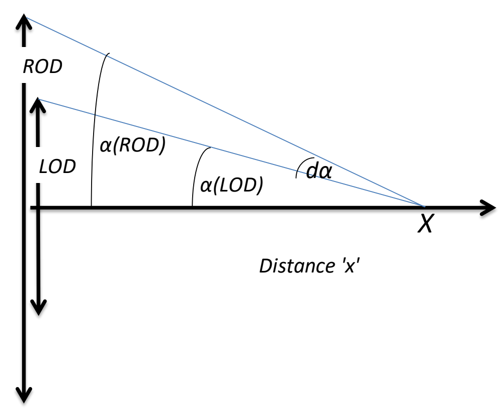

Fig.10.2: *Photon* Course Change $d\alpha$

In this figure:

- ✓ $\alpha_{(ROD)}$ is the angle at which we see the *Photon* incoming.

- ✓ $\alpha_{(LOD)}$ is the angle towards the reckoned emission point.
- ✓ $d\alpha$ is the difference between both.

We define R_R as the Remotely observed orbit Radius:

$$R_R = ROD/2 \tag{10.1}$$

And we define R_L as the reckoned Local orbit Radius:

$$R_L = LOD/2 \tag{10.2}$$

At distance x the tangent of $\alpha_{(ROD)}$ then equals:

$$\tan(\alpha_{ROD}) = \frac{R_R}{x} \tag{10.3}$$

And the tangent of $\alpha_{(LOD)}$ equals:

$$\tan(\alpha_{LOD}) = \frac{R_L}{x} \tag{10.4}$$

Per equation (9.8) we find:

$$\frac{LOD}{2} = \cos\left(\frac{\text{v}_{orbit}}{c}\right).\frac{ROD}{2}$$

Or:

$$R_L = \cos\left(\frac{\text{v}_{orbit}}{c}\right).R_R$$

We substitute this in equation (10.4):

$$\tan(\alpha_{LOD}) = \frac{\cos\left(\frac{\text{v}_{orbit}}{c}\right).R_R}{x} \tag{10.5}$$

The angle $d\alpha$ then equals:

$$d\alpha = \tan^{-1}\left\{\frac{R_R}{x}\right\} - \tan^{-1}\left\{\frac{\cos\left(\frac{\text{v}_{orbit}}{c}\right).R_R}{x}\right\} \tag{10.6}$$

The above equation can be normalized by expressing *distance x* in the number of R_R's. For this purpose, we define a new *distance UoM* named x_R, whereby $x_R=x/R_R$. Equation (10.6) then normalizes to:

$$d\alpha = \tan^{-1}\left\{\frac{1}{x_R}\right\} - \tan^{-1}\left\{\frac{\cos\left(\frac{\text{v}_{orbit}}{c}\right)}{x_R}\right\} \tag{10.7}$$

(x_R expressed in orbit radiuses R_R)

The following figure shows $d\alpha$ (in *radials*) per the above equation, as a function of *distance* x_R from the orbit centre. We thereby opted for the maximum possible orbit *velocity* $\text{v}_{orbit}=c$. The reason is that this fits the modelling of an *Entropy-Atom* (to be detailed in Chapter 12).

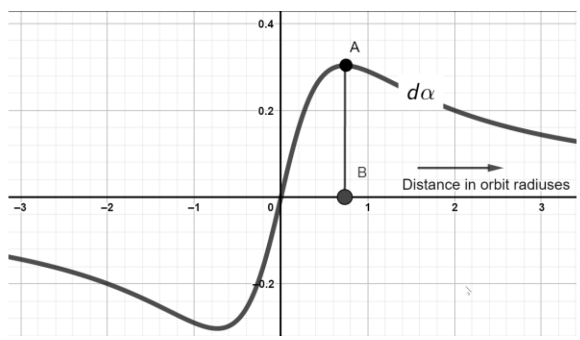

Fig.10.3: $d\alpha$ (in *radials*) as a Function of *Distance* x_R
(x_R expressed in number of R_R's from the orbit centre, whereby the orbit *velocity* $\text{v}_{orbit}=c$)

The *gradient* in *Whereabouts pressure* at any point on the orbit axis, is quantified by the local steepness in the above shown curve, thus by $\frac{d\alpha}{dx_R}$.

Based on equation (10.7):

$$\frac{d\alpha}{dx_R} = \frac{x_R^2.\left(\cos\left(\frac{v_{orbit}}{c}\right)-1\right)+\left(\cos\left(\frac{v_{orbit}}{c}\right)-\cos^2\left(\frac{v_{orbit}}{c}\right)\right)}{x_R^2.\left(\cos^2\left(\frac{v_{orbit}}{c}\right)+1\right)+x_R^4+\cos^2\left(\frac{v_{orbit}}{c}\right)}$$	10.8

x_R expressed in remotely observed orbit radiuses R_R

The following figure embeds the value thereof:

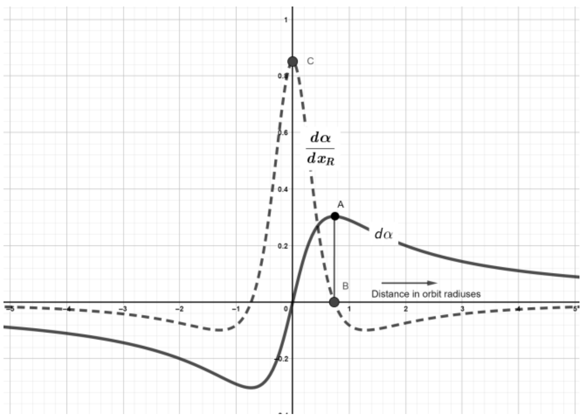

Fig.10.4: *Gradient* $\frac{d\alpha}{dx_R}$
(as a function of *distance* x_R expressed in R_R*'s*, based on an orbit *velocity* $v_{orbit}=c$)

The *gradient* in the local *Whereabouts pressure* ($\frac{d\alpha}{dx_R}$) was identified as the **cause** of *Gravity*, not necessarily a one-to-one representation of the **strength** of the gravitational force. We will explore the actual strength later. At this point in our analyses, we expect nothing more than the gravitational force to be **proportional** to this *gradient*.

Nevertheless, figure (10.4) already leads to the following two findings:

1. The *gradient* changes sign at the point marked B, located at the *distance* of approximately 0.7 times the remotely observed orbit radius R_R (at either side of the orbiting centre).
   This implies that, at a shorter *distance* as marked by point B, the gravitational force changes sign from attracting to repelling.
2. We find a finite maximum repelling force at the centre of the orbiting system, at the point marked C.

The above two findings deviate from mainstream physics.

Two case studies at the end of the chapter, address how, at least conceptually these findings fit actual observations. A third case study describes a potential means of experimentally verifying the validity of the above.

The exact *distance* at which the gravitational force changes sign (point B in figure (10.4)) is found where the numerator in equation (10.8) equals 0:

$$x_R^2.\left(\cos\left(\frac{v_{orbit}}{c}\right)-1\right)+\left(\cos\left(\frac{v_{orbit}}{c}\right)-\cos^2\left(\frac{v_{orbit}}{c}\right)\right)=0$$

This gives the following two values for *distance* x_R:

$$x_R = \pm\frac{\sqrt{-4.\left(\cos\left(\frac{v_{orbit}}{c}\right)-1\right).\left(\cos\left(\frac{v_{orbit}}{c}\right)-\cos^2\left(\frac{v_{orbit}}{c}\right)\right)}}{2.\left(\cos\left(\frac{v_{orbit}}{c}\right)-1\right)}$$

If we assume $v_{orbit}=c$ (as applicable to *Entropy-Atoms*) the result is…

$$x_R = \pm\frac{\sqrt{-4.(\cos(1)-1).\left(\cos(1)-\cos^2(1)\right)}}{2.(\cos(1)-1)}$$

$$= 0.735052587\ ...$$

…or, because R_R is the normalized *UoM* for *distance*:

$$x = \pm 0.735052587\ ... \times R_R$$

We conclude that for $v_{orbit}=c$ (as applicable to *Entropy-Atoms*) the gravitational force changes from attracting towards repelling at the *distance* of 0.735052587… times the orbit radius R_R from the orbit centre.

d) Estimated Whereabouts Curving at Large Distances

For large values of x_R, thus at a large *distance* from the orbiting system relative to the orbit radius, equation (10.7)…

$$d\alpha = \tan^{-1}\left\{\frac{1}{x_R}\right\} - \tan^{-1}\left\{\frac{\cos\left(\frac{v_{orbit}}{c}\right)}{x_R}\right\}$$

… is approximated by:

$$d\alpha_{large\ x_R} \approx \frac{1}{x_R} \times \left(1-\cos\left(\frac{v_{orbit}}{c}\right)\right)$$	10.9

For large x_R

The following figure shows both curves, again based on an orbit *velocity* $v_{orbit}=c$:

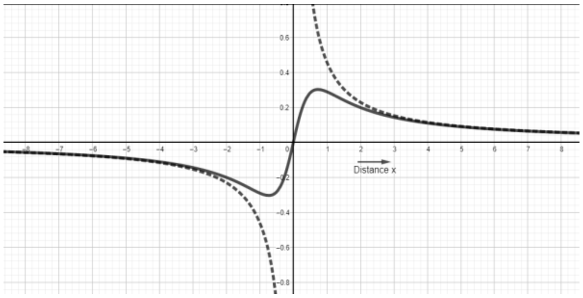

Fig.10.5: Estimated $d\alpha$

(based on an orbit *velocity* $v_{orbit}=c$, *distance* x_R expressed in R_R)

The figure shows that both curves indeed approach one another as the *distance* x_R towards the orbiting system grows. At the *distance* of 500 R_R*'s,* for example, the relative difference is reduced to 0.0002 %.

Per equation (10.9) the estimated *gradient* in $d\alpha$ equals:

$\frac{d\alpha}{dx_R} \approx \frac{1-\cos\left(\frac{v_{orbit}}{c}\right)}{x_R{}^2}$	10.10

(estimate for large *distances* x_R)
(x_R expressed in remotely observed orbit radiuses R_R)

The following figure shows the difference between the exact *gradient* per equation (10.8) and the estimated value per equation (10.10), again based on orbit *velocity* $v_{orbit}=c$:

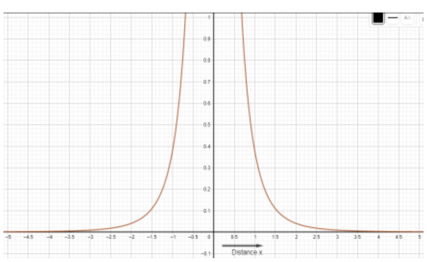

Fig.10.6: Error in $\frac{d\alpha}{dx}$ per estimated Equation (10.10)

(based on an orbit *velocity* $v_{orbit}=c$, *distance x* expressed in R_R)

Notice the rapidly decreasing error as the *distance* towards the orbiting system increases.

e) The Gradient in Whereabouts Pressure Equals the Gravitational Force

We reasoned that the *gradient* $d\alpha/_{dx}$ is proportional to, but not necessarily equal to the gravitational force. There is still room for a constant scale factor which would have a value other than numerical 1.

Let us explore this for *Entropy-Atoms*.

For *Entropy-Atoms* v_{orbit} equals 1 and equation (10.6) can be written as:

$$d\alpha = tan^{-1}\left\{\frac{R_R}{x}\right\} - tan^{-1}\left\{\frac{\cos(1).R_R}{x}\right\}$$

The *gradient* $\frac{d\alpha}{dx}$ equals:

$$\frac{d\alpha}{dx} = \frac{R_R.x^2.(\cos(1)-1) + R_R{}^3.\left(cos(1) - cos^2(1)\right)}{R_R{}^2.x^2.(cos^2(1)+1) + x^4 + R_R{}^4.cos^2(1)}$$

For very large values of *distance x,* as well as for very small values of R_R, the above equation is estimated by:

$\frac{d\alpha}{dx} \approx \left(1-\cos(1)\right) \times \frac{ROD}{x^2}$	10.11

(for Entropy Atoms at large *x*)

Per equation (9.8) the term 'cos(1)' can be replaced by *LOD/ROD*:

$$\frac{d\alpha}{dx}_{large\ x\ or\ small\ R} \approx \left(1-\frac{LOD}{ROD}\right) \times \frac{ROD}{x^2}$$

Or:

$\frac{d\alpha}{dx}_{large\ x\ or\ small\ R} \approx (ROD - LOD) \times \frac{1}{x^2}$	10.12

In the above equation the term *(ROD-LOD)* reflects the quantity of 'fake' *Whereabouts*. Recall that from a remote location we see an orbit diameter equal to the *ROD*, but we know that we see it enlarged, as if looking through a magnifying glass. The difference *(ROD-LOD)*, being 'fake' *Whereabouts*, is per the *Crenel Physics* model to be interpreted as an amount of dilution of *Whereabouts*. This quantity of *Whereabouts* does not truly exist.

We see 'fake' *Whereabouts* that do not 'truly' exist as these appear as *Content*. The *Crenel Physics* model demands that one unit of *Whereabouts* converts one-to-one into one unit of *Content*. To reflect this requirement, we write equation (10.12) as…

$$\frac{d\alpha}{dx_{large\ x\ or\ small\ R}} \approx \frac{Content_1}{x^2} \qquad (10.13)$$

…so that $Content_1$ represents the *Content* embedded within the orbiting system.

We can now make a direct comparison with Newton's gravitational equation:

$$F_G = G \times \frac{Content_1 \times Content_2}{x^2} \qquad (10.14)$$

This is a fundamental equation that must hold within any system of *UoM*, even though the *Crenel Physics* model demonstrates that it is no more than a good approximation of the gravitational force at large (relative to the orbit diameter of orbiting induced *Content*) *distances*.

We substitute equation (10.13) in Newton's equation (10.14):

$$F_G = G \times \frac{d\alpha}{dx_{large\ x\ or\ small\ R}} \times Content_2 \qquad (10.15)$$

Prior to interpreting the physical meaning of this equation, let us check its dimensional integrity within the *Crenel Physics* model.

The dimensions of the individual terms are:

- ✓ F_G is to be expressed in P/C (Chapter 1).
- ✓ G equals 1 C/P (Chapter 1).
- ✓ $\frac{d\alpha}{dx_{large\ x\ or\ small\ R}}$ is in $^P/_{C^2}$ per equation (10.19).
- ✓ $Content_2$ is in *P*.

Substituting these dimensions into equation (10.15) gives:

$$\frac{P}{C} = \frac{C}{P} \times \frac{P}{C^2} \times P = \frac{P}{C} \qquad (10.16)$$

This confirms the dimensional integrity of equation (10.15).

Based on equation (10.16) we can now 'upgrade' the meaning of *gradient* $\frac{d\alpha}{dx_{large\ x\ or\ small\ R}}$.

Per the *Crenel Physics* model, this *gradient* quantifies the strength of the gravitational field at large *distances* caused by $Content_1$, whereby the scale factor is found to equal 1.

(65) The *gradient* in *Whereabouts* pressure equals the gravitational force.

Note that the above 'upgrade' is based on the presumed match between Newton's gravitational equation and the long-distance estimated outcome of the gravitational force per the *Crenel Physics* model.

(66) Currently there is no experimental verification that, at shorter *distances,* the *Crenel Physics* model is correct.

f) The Observer's Location

Thus far our calculations were based on an observer who is remotely located somewhere on the axis of an orbiting system. With the orbit plane being perpendicular to this axis, the entire system is 3-dimensional. Another location relative to the orbiting system, for example at some distance away from the axis, would complicate the math. It would also impact the outcome.

Alternatively, we can position the observer somewhere on the plane of the orbiting system. This would lead to the same math. Thereby the observer would see both objects 'A' and 'B' oscillate relative to a centre point of *Gravity* along some remote line.

g) Case Studies

The following case studies give some suggestions for further evaluations and verifications.

Case Study #1:

Consider an orbiting galactic system that consists of numerous masses. Per the Newtonian gravitational equation, the net gravitational force at the centre of such system would equal 0, as the gravitational forces induced by all surrounding masses would compensate each other.
In the Newtonian model, ultimately the system

would take the shape of a perfectly flat (2-dimensional) disc. However, we never find galactic systems completely flattened, despite their age.
Per the *Crenel Physics* model, an object which is located near the centre of such an orbiting galactic system would experience a finite gravitational repelling force, directed away from the centre. Such systems would therefore ultimately maintain some thickness that is largest at the centre. This not only fits actual observations, but the *Crenel Physics* model explains (and might even quantify) the ultimate 3-dimensional parameters of such systems.

Case Study #2:

Consider a proton and an *electron* in orbit around their centre of gravity. Per the *Crenel Physics* model, an approaching electrically neutral particle (such as a neutron) would not settle itself at that centre. Here, it would be subject to a finite repelling gravitational force. Note that a hypothetical orbiting *velocity* of an electron would be in the order of 1% of light *velocity*.
Atoms are indeed 3-dimensional objects rather than flat discs. This fits the *Crenel Physics* model.

Case Study #3:

Consider a spaceship on its way from Earth to the Moon. It would thereby pass the centre of gravity of the Earth/Moon orbiting system at relatively close range.
Per the *Crenel Physics* model, it would experience a (small) non-Newtonian gravitational force which is directed away from the centre of gravity and perpendicular to its course. Thus, the spaceship would experience a minor course deviation away from the targeted Moon, strongest when passing the centre of *mass* of the Earth-Moon orbiting system.
A (statistical) analyses of these deviations might be a method to verify the here presented model, perhaps only in concept. On average course deviations should then be found largest near the centre of gravity of the Earth/Moon orbiting system.

(11) A *Photon* Colliding with a *Mono-Bit*

Now to address the collision between a *Photon* and a *Mono-Bit* in an otherwise empty space. As we will discuss in Chapter 12, such a collision will evolve in the creation of an *Entropy Atom*. But prior to that we will focus on the collision itself.

At first sight a 'collision' demands that two objects have equal *Whereabouts* coordinates. Within a 4-dimensional time-space and at some instantaneous moment, they have equal spatial coordinates. Should nature surprise us with a 5th *Whereabouts* coordinate (or *Appearance* thereof), it too must have an equal value between both objects.

> *We always see a collision when the afore mentioned 4 coordinates are equal. This suggests that nature offers no additional coordinates.*

Closer inspection reveals that it is impossible to meet the demand for equal coordinates. Questions like, '**where** exactly is the object?' have ambiguous answers. Consider objects that have a spatial size. With billiard balls, for example, we still can do our estimations. But at sub-atomic scale things become more diffused. The *Crenel Physics* model adds to the ambiguity in that any *Content* is equal to an inversion of *Whereabouts* which reveals itself as a distortion in the *Whereabouts* frame of reference. So where in this distortion does the *Content* reside? At most we would be able to pinpoint the centre of gravity thereof, whereby we still would be subject to Heisenberg's uncertainty principles.

The two objects we picked for our collision have different properties. The *Photon* will embed *Content* originating from its source, whereas an isolated *Mono-Bit* cannot. As we saw in Chapter 6, the *Mono-Bit* holds one *bit* of *Entropy* in a static state. It is only hypothetically *observable* and is certainly not *verifiable*.

These properties raise two questions with regards to such a collision:

1. Can a *Mono-Bit* nevertheless absorb *Content*?
2. If so, would it make a difference if the collision were 'head on' or at some other angle?

As said, Chapter 12 will explain how such a collision causes a *Mono-Bit* to convert into an *Entropy-Atom*. The first question will therefore be positively answered since the newly formed *Entropy-Atom* is a 2-*bit* object that can indeed absorb *Content*.

The second question is relevant upfront since the parameters prior to the collision dictate the outcome. We therefore need to identify these.

a) Collision Parameters

Let's begin by reviewing the collision between a *Photon* and an *electron* that is a part of an atom. For such a scenario, detailed experimental data is available.

When a *Photon* collides with an atom's *electron*, the *electron* may jump to a higher *energy* level within the atom, in which case the *Photon* disappears. Experimental data demonstrates that this energy transfer is 'all or nothing'. A *Photon* with, for example, twice the amount of demanded *energy* does not invoke such a jump.

This experimental finding is consistent with the *Crenel Physics* model of a *Photon*. A partial *energy* transfer would result in an *observable* electron's *energy* jump, while the original *Photon* would not completely vanish. Per *Crenel Physics*, *Photons* can only cause *observable* events by their complete disappearance.

As an example, figure (11.1) shows 6 electron energy levels numbered n=1 thru n=6, as found within a hydrogen atom. The electron's ground level corresponds to n=1.

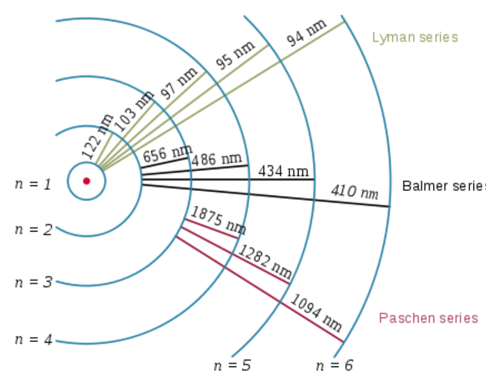

Fig.11.1: Electron Energy Levels as found within a Hydrogen Atom
Credit: Wikipedia

Based on this example, we can experimentally verify the 'all or nothing' principle by analysing the *Photon's* **absorption** and **emission** spectra.

Absorption:
When we shine a beam of white light through hydrogen gas (i.e., light with a continuous energy spectrum), the outcoming light spectrum will show sharp interruptions known as absorption lines.
The *energy* levels associated with these spectral absorption lines relate one-to-one to electron *energy* jumps within the atom. Partial *energy* transfers from *Photons* to *electrons* are not found. This would result in an increase of lower energy *Photons*, thus in relatively brighter light at the lower *energy* side of the outcoming absorption spectrum. Such is not observed.
In addition, we will not observe multiple *Photons* combining their *Content* to make an electron jump towards a higher *energy* level. Consistent with the *Crenel Physics* model, each *Photon* embeds 1 *nat* of *Entropy*, so that this scenario would result in an *Entropy* loss of multiple *nat.* Only one *nat* would be recovered during the subsequent emission: when the electron returns to its original *energy* level. The consequential net *Entropy* loss would conflict with the second law of thermodynamics (Chapter 5).

Emission:
At some later moment in *time*, the light emission spectra of atoms will be caused by an *electron* falling back to a lower energy level. In some random direction, the *electron* then emits one single *Photon* that embeds the exact *energy* difference between both levels, plus one *nat* of *Entropy*.
So again, we see this one-to-one relationship.
As figure (11.1) illustrates, both upward jumps as well as fall backs can be between any two *energy* levels. Where the absorption of a *Photon* will only cause one single jump up (e.g., from n=1 to n=5), the subsequent fall-back may be in multiple steps (e.g., from n=5 to n=4 to n=2 to n=1). Such would then produce 3 *Photons* so that 3 *nat* of *Entropy* is created while 1 *nat* was lost in the absorbed *Photon*. This scenario would result in a net *Entropy* gain of 2 *nat* in compliance with the second law of thermodynamics.

Note that we can differentiate between the absorption spectrum and the emission spectrum by directing a beam of light through some hydrogen gas. The absorption spectrum will exclusively be found in the outcoming beam, whereas the emission spectrum will be found anywhere around the gas since the individual *Photon* emissions are in random directions.

To our analyses, the most relevant observation is that the bandwidths of both the absorption as well as the emission spectral lines are found to be extremely narrow, once compensated for Doppler shifts associated with atom velocities relative to the observer.

Consider the sodium spectrum. It is dominated by a ‘two lines doublet’ known as the Sodium D-lines with wavelengths of 588.9950 *nm* and 589.5924 *nm* respectively. As these values show, these spectral lines were measured with an accuracy of 7 *digit*s so that their bandwidth is at most 0.00001% (corresponding to these 7 *digit*s).

> *Where larger bandwidths or shifts of bands are found, these are explained by the Doppler shift associated with the movement of the atom as a whole object relative to the observer.*

These very narrow bandwidths are remarkable, as (from a classical viewpoint) *electrons* within an atom are presumed to be dynamic particles. Should we assign a hypothetical *velocity* to their ‘position’, based upon the viewpoint that an electron orbits as a negatively charged particle around the positively charged atom’s nucleus, we would find it to have a value in the order of magnitude of 1% of the *velocity* of light. Should then the electron’s velocity direction act upon the outcome of the collision with a *Photon*, due to a Doppler shift, this would result in a minimum bandwidth in the order of +/- 1%, pending the electron moving to or from the incoming *Photon*. This would then apply to both the absorption as well as the emission spectral lines. But in fact, these bandwidths are found extremely narrow. This demonstrates that, within high measuring accuracy, there is **directional indifference** in *energy* transfer when it comes to a collision between a *Photon* and an *electron* embedded within an atom.

> *This finding led to the development of atomic clocks which in concept are based on the stability and extremely narrow bandwidths of spectral lines.*

The envisioning of electrons within an atom as orbiting objects therefore fails. The experimental data demonstrate that electrons within an atom have neither a *velocity* nor a direction. Instead, we envision a higher or lower probability for ‘finding’ them at some location. The electron thereby appears ‘diluted’ over some ‘probability region’. The locations of highest probability are calculated as orbit-like shapes, with rapidly diminishing chances as the *distance* to these shapes increases. Within such a region, the concept of '*velocity*' (or some direction thereof) does not hold.

From this we envision that a *Photon* collides with the entire probability region in which the electron can be found. Even the shape of this probability region proves to be irrelevant to the collision's outcome. We find narrow bandwidths in all cases. The following figure illustrates some potential shapes for such probability regions.

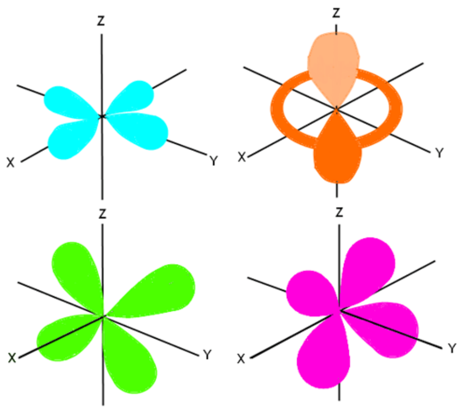

Fig. 11.2: Examples of potential Probability Regions of an Electron's Location within an Atom
Credit: Wikipedia

Based on these findings we postulate that this same directional indifference exists when it comes to a collision between a *Photon* and a *Mono-Bit*.

b) Applying Heisenberg's Uncertainty Principle

Per the above postulation the *Mono-Bit*, as an electron within an atom, also resides in a probability region. However, in the absence of a binding nucleus, that region covers the entire universe, with equal probability anywhere at any time. As found in the previously described case of an electron within an atom, within its probability region, the *Mono-Bit* likewise has neither a defined velocity nor direction. The *Photon* thus does not collide with a *Mono-Bit* 'particle' but instead with the entire probability region thereof.

The above envisioning is consistent with Heisenberg's *uncertainty* principle (Chapter 4). In this case, we know the *impulse* as well as the *energy* of an isolated *Mono-Bit*: both have the exact value of 0. Consequently, per Heisenberg, there is no certainty whatsoever as to the *Mono-Bit's* location at any given time. Or: we have no *Information* (i.e., '*resolution to uncertainty*') as to their *Whereabouts*. We can thus think of *Whereabouts* as a homogeneous thick or thin 'soup' of *Mono-Bits* which provide the 'hardware' (or *entropy*) to potentially create *Content*.

(12) Construction of the *Entropy-Atom*

We defined an *Entropy-Atom* as a system of two *Mono-Bits* in orbit. The reason for selecting *Mono-Bits* will be explained later.

But how likely is the shaping of such an orbiting system? Let's start by reviewing the passing by of a single *Mono-Bit*.

a) A Mono-Bit Passing By

Mono-Bits are containers of *Entropy*. They can store 1 *bit* thereof. When isolated in empty space, in lack of any interaction option, their *frequency* of state changing υ equals 0. Per the enhanced Planck equation, $E = h.\nu.S_{(nat)}$, their *Content* thus is known without any uncertainty: it equals exactly 0.

Per Heisenberg's uncertainty principle (see equation (4.25): $\Delta P.\Delta C = \frac{h_{CP}}{2}$), the value of the error in *Content* ΔP then equals 0 *Packages*. The error then in *Whereabouts* ΔC is infinite in *Crenels*. We therefore have no *Information* whatsoever with regards to a *Mono-Bits Whereabouts*. Any *Whereabouts* value (or coordinate) has validity with an equal non-zero probability.

As we will see, any presumption with regards to some specific *Whereabouts* coordinates does not act upon the outcome of our analyses.

Consider a 1-dimensional spatial universe. This presumes that an isolated *Mono-Bit* is residing within that space (that is, on some imaginary line). Given Heisenberg's uncertainty principle, at any moment in time and with equal probability, it can be found anywhere on that line.

> *This feature also ensures that one bit of Information, when stored within the Mono-Bit, is instantaneously available along the entire line. This is consistent with our findings in Chapter 4, that Information is universally 'available' and does not travel.*

Per our model:

- ✓ The *Mono-Bit* is anywhere at the same time.
- ✓ There is a non-zero probability that we can find the *Mono-Bit* at some specific location.

At some moment in time, should we find it at some location 'A', this would inherently imply that within the next second it's new location relative to 'A' is limited by its velocity which cannot exceed light velocity *c*. At first sight, this implication contradicts the requirement of equal probability along the entire line at any given time. This requirement can nevertheless be met by assigning an infinite physical length L_0 to the *Mono-Bit*. We define:

$\boldsymbol{L_0 = \infty}$	12.1

Yet there is still the requirement that, at any given moment in time, there must be some non-zero probability to find the *Mono-Bit* at some specific location 'A' on that line. This demands that the length *L,* from our perspective, equals 0. If not, we would not be able to confirm that, for example, it resides at location 'A' and therefore not at any other location.

$\boldsymbol{L = 0}$	12.2

The solution for finding a different length between 'locally' and 'relative to an observer' is found in the Lorentz contraction:

$\boldsymbol{L = L_0\sqrt{1 - \mathrm{v}^2/c^2}}$	12.3

The Lorentz contraction quantifies the (shorter) observed object length *L* relative to its local length L_0, pending its velocity 'v' relative to the observer.

Per equation (12.3) both demands per (12.1) and (12.2) are met if the *Mono-Bit* has a relative velocity 'v' equal to light velocity *c*.

It is paramount that per the *Crenel Physics*, *velocity* is found to be dimensionless. In being a dimensionless property, it cannot be subject to relativity and is thus universally equal. Not only does this explain why light velocity relative to any observer is universally equal, but it also ensures that both requirements per (12.1) and (12.2) are indeed met for all observers regardless of their relative circumstances.

To enhance our model from a 1-dimensional to a 3-dimensional spatial universe, consider a *Mono-Bit* in its 1-dimensional space as described in the above. It has length $L=0$ and $L_0 = \infty$, and travels along some straight line at light velocity c. With equal probability, that 1-dimensional line can be found anywhere within a 3-dimensional space and can be pointing in any direction. Again, we see that each option has equal probability.

The following figure shows one instance thereof:

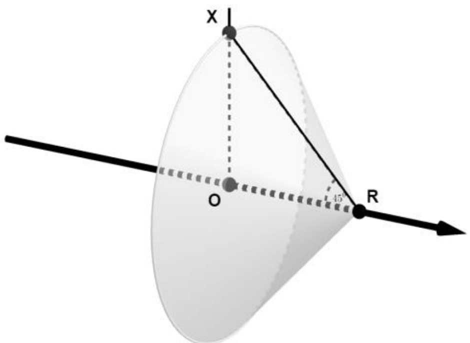

Fig.12.1: A *Mono-Bit* residing on an imaginary Line

There is a non-zero chance that the *Mono-Bit* is at location 'O'. At some remote location 'X' away from that line and by some hypothetical remote interaction mechanism, a sensor may sense the *Mono-Bit* at that location. Such hypothetical remote sensing would be retarded. The retardation *time* would equal OX/$v_{interaction}$, whereby the hypothetical interaction mechanism between *Mono-Bit* and sensor is presumed to travel at *velocity* '$v_{interaction}$'.

Since we found that the *Mono-Bit* is traveling at light velocity *c,* during this retardation time the *Mono-Bit* would have progressed to point 'R'.

To facilitate further analysis, we imagine that the *Mono-Bit* is dragging a circular cone as shown in figure (12.1). The hypothetical sensing at point 'O' would then occur when the surface of this imaginary cone passes the observation location 'X'.

The *Mono-Bit* would not physically have to travel to point 'R' to invoke such hypothetical retarded sensing. The single fact that it hypothetically may be sensed to reside at location 'O' is enough to explain the above.

b) A Course Change Reveals a Twin

Assume that for some unknown reason, at location 'O', the *Mono-Bit* changes course with some angle dα. As we will see, such invokes an observable event. This disqualifies substitution of a *Photon* for our *Mono-Bit* as *Photons* cannot create observable events during their lifetime.

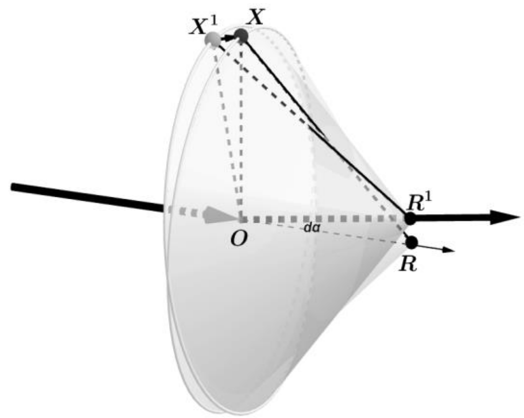

Fig. 12.2: a Course change $d\alpha$ at 'O'

Any course change will kick the *Mono-Bit* into an initial orbit. This has consequences.

First, starting from location 'O', this kick will cause at least a spike in 'Planck based *Content*' per equation $E = h.\nu.S_{(nat)}$. This in turn invokes at least a spike in *Gravity.* The latter can be remotely sensed without a doubt. Of greater significance, no tangible object could possibly be exempted from being impacted by this spike.

Gravity travels at light *velocity*. Both the afore mentioned hypothetical interaction mechanism between *Mono-Bit* and sensor, as well as the *Mono-Bit* itself, are found to travel at light velocity. The aperture angle of the cone in figures (12.1) and (12.2) therefore is 90^0.

Second, the course change $d\alpha$ causes the axis of the imaginary cone to change direction accordingly. Figure (12.2) shows that a point marked 'X^1' on the now redirected cone is still heading towards the remote observation location 'X'.

> *In this figure we assumed that the course change $d\alpha$ has a directional component **towards** the observation location and not **away** from it. We will address the latter scenario.*

Consequently, at our remote observation location, a second hypothetical observation of the *Mono-Bit's* passing would be imminent, namely when point 'X^1' on the now redirected cone passes.

From this we conclude:

(67) Due to the course change, the original *Mono-Bit* receives an apparent trailing twin.

It is not relevant that the observation of a single *Mono-Bit* passing is only hypothetical. The gravitational spike is real. Where the first passing then marked the beginning of this spike, the second passing marks the end thereof.

> *Per the Crenel Physics model, Content is equal to an inversion of Whereabouts. Here we received a first glimpse of what such an inversion, apart from being a mathematical operation, looks like from a physical perspective: a local curve in a Whereabouts gridline.*

The above may raise questions with regards to the conservation principles.

A first question would relate to the apparent doubling of embedded *Information* from 1 *bit* prior to the course change, to 2 *bits* thereafter. As we saw in Chapter 4, *Information* can be copied without costs. This doubling therefore can be accepted without objection. Also, this doubling from one *bit* to two *bits* is in line with the second law of thermodynamics. This law demands an ultimate equality or raise in *Entropy* after any event.

Referring to the *enhanced Planck equation* (4.24) the Planck based *Content* is now materialized by an *Entropy* (i.e.: *Information* storage capacity) of two *Mono-Bits* rather than one. Since we classified *Entropy* as a '*hardware*' property, this also demands some further analyses. For the doubled observation, the spatial parameters demand that the course change $d\alpha$ has a directional component **towards** the remote observation location. Such only applies to one half of the cone surface. At the other half, no observation at all will take place.

The following figure illustrates this 2-dimensionally:

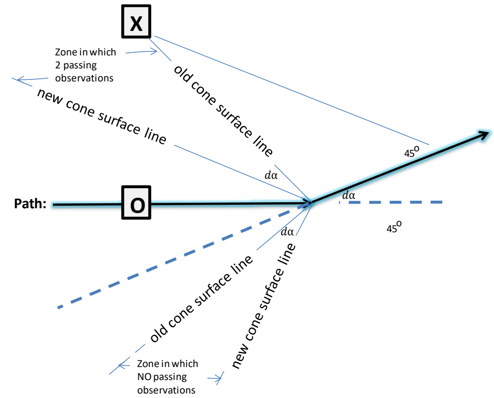

Fig.12.3: Cone Zone in which **two** Passes are observed, and Zone in which **no** Passes are observed

At some random remote point on the imaginary cone surface, there is equal probability between two observations and no observation at all. On average then, the conservation principle is not violated by introducing the trailing twin.

We conclude that:

(68) From a remote perspective, a course change of a *Mono-Bit* results in the birth of a 2-*bit* object: the birth of an *Entropy-Atom*.

Presuming that the initiated orbiting will endure, we may compare the *Entropy-Atom* with a lighthouse. At any location, for each full orbit of the *Mono-Bit* pair (full rotation of the light beam), we will receive a spike in *gravity* (a single flash of light). Given a certain course change, the duration of that spike (flash) will be universally equal, regardless of the distance from the event (lighthouse).

c) *A Potential Cause for a Course Change*

As discussed in Chapter 11, the collision of a *Photon* with any object causes a full transfer of the *Photon's energy*. Based on the properties of a *Photon*, partial transfers are not allowed.

The course of a *Mono-Bit,* prior to the collision with a *Photon*, has no impact. For all potential courses, the collision will cause an instantaneous course change $d\alpha$ which will exclusively depend on the properties of the initial *Photon*.

Course change $d\alpha$ in turn, defines the properties of the newly born *Entropy-Atom*. We apply the enhanced Planck equation (4.24)…

$E = h.\upsilon.S_{(nat)}$

…whereby for the *Entropy-Atom*, $S_{(nat)}$= *ln(4)*:

$\boldsymbol{E_{EA} = h.\upsilon_{EA}.\ln(4)}$	12.4

The initial *Photon*'s *energy* equals:

$\boldsymbol{E_{Photon} = h.\upsilon_{Photon}}$	12.5

Based on the *energy* conservation principle and the consideration that the initial *Mono-Bit* did not contain energy, we demand:

$E_{Photon} = E_{EA}$

So that we find:

$\boldsymbol{\upsilon_{EA} = \frac{\upsilon_{photon}}{\ln(4)}}$	12.6

We thus assign a *frequency* to the newly born *Entropy-Atom* so that we can envision it as an initiated orbiting system.

Prior to demonstrating that the orbit will persist, we explore the conservation of *momentum*.

d) Momentum Transfer

In the previous chapter we postulated a plausible similarity with a collision of a *Photon* with an *electron's* probability region within an atom. In the latter case, the *Photon* collides with the entire electron's probability region and its momentum is absorbed by the atom, of which the constituents indeed behave (within limits) as one single target.

In the case at hand, the *Photon's* momentum is likewise to be absorbed by the entire probability region (i.e., the entire universe) in which the *Mono-Bit* can be found. Since the *Mono-Bit* is weightless, the creation of verifiable *Content* (i.e., the *Entropy Atom*) inherently comes with a kick towards a *Whereabouts* expansion at maximum (light) velocity. Based on this viewpoint, the universe started its expansion at the same moment in which the first *Content* was created. Why else would the universe expand?

e) The Initiated Orbit will Persist

If the associated Planck based *Content* is physically held by the two *Mono-Bits* within the *Entropy-Atom* at hand then, due to their inertia, the *Mono-Bits* would spin out of their initial curve. However, the finding that there **is** indeed *Content* does not demand its attachment to the *Entropy* embedding entities themselves (in this case, the two *Mono-Bits* that jointly constitute the *Entropy-Atom)*.

In the following we will argue why the associated *Content* is not held by (or attached to) the orbiting *Mono-Bits*, but instead is represented by the curving of *Whereabouts*. The curving of *Whereabouts* **is** the *Content*, and *Mono-Bits* will sharply follow that curving without spin-out.

First, we compare this viewpoint with the previous modelling of *Photons* (Chapter 5). We found that a *Photon* (i.e., a weightless *Entropy* container) will follow the shortest *Whereabouts* path between two points. That path must also represent its *frequency*, thus have a spiral shape. That spiral defines a probability region for a *Photon*. Within a 3-dimensional space this would have the shape of a cylinder, in which the *Photon* can be found. Within a 2-dimensional space it would have the shape of a ribbon. It would not be possible to fit a *Photon* into a 1-dimensional space, as such space does not provide the degree of freedom to oscillate at some *frequency* while maintaining a constant *velocity*.

Compare this to the previously described 1-dimensional line that represented the probability region of a *Mono-Bit*, whereby $L_0 = \infty$, $L = 0$, and v = light velocity *c*.

This comparison suggests that:

(69) The *Mono-Bit* can be seen as the one-dimensional version of a *Photon*.

The actual usage of the available spatial degrees of freedom is then reflected in that a *Photon* embeds a larger *Entropy* value relative to the *Mono-Bit* (1 *nat* versus 1 *bit*). It allows a single *Photon*, within an otherwise empty space, to embed a *frequency*.

The *wavelength*, combined with the *Photon's* velocity, dictate this *frequency* and thereby the *Photon's Content*. In a 3-dimensional space we give it a spiral shape (a sinusoidal wave). The effective length thereof, relative to adjacent gridlines, appears shortened. This shortening represents a local deficit in *Whereabouts*. It is equivalent to *Content*, in that we found *P.C=1*. The shorter the wavelength (i.e., narrower the tube), the higher the deficit in *Whereabouts* and the larger the embedded *Content*. This reflects Planck's equation $E = h.\nu$.

Within the newly born *Entropy-Atom*, we likewise have a weightless *Entropy* container, embedding 2 *bits* of *Entropy*. It too will follow curved *Whereabouts* paths without spin-out. Here we likewise have an initial curving of a *Whereabouts* gridline. In essence, the collision between a *Photon* and a *Mono-Bit* therefore did not truly cause the *Mono-Bit* to change course, as previously suggested. Instead, it caused the local *Whereabouts* gridline to curl up.

If then such gridline is locally curved by the collision event, there is no firm reason why such curving will be restricted to the region of the collision. Such initiated curving may endure. If so, the local *Whereabouts* gridline transforms into a closed loop or full circle. This closed loop then defines the orbit along which the initial *Mono-Bit* will start orbiting. When seen from a remote perspective, it will be followed by an apparent trailing twin. It is the curled-up orbit path that represents the *Content*. Its radius may be infinite, corresponding to no deficit in *Whereabouts*, and thereby corresponding to no *Content*. Or its radius may have some finite value which would shorten the orbit path proportionally and create a deficit in *Whereabouts*. This deficit **is** *Content*.

Previously, we identified *Content* as inverted *Whereabouts* without having a perception as to what this 'inversion' operation would look like when seen from a physical perspective. Here we found that an originally straight and thus 'open' *Whereabouts* gridline is converted into a closed loop.

Based on this:

**(70) The 'inversion' of *Whereabouts*, and thus the creation of *Content*, is equivalent to the transformation of a straight *Whereabouts* gridline into a closed loop.
When seen from a remote perspective, it defines the orbit as followed by the two *Mono-Bits* within an *Entropy-Atom*.**

From this perspective:

(71) We can envision the (remotely observed) leading *Mono-Bit* and its trailing twin as a 'string'.

f) String Length

Let's now review a local system in which two *Mono-Bits* jointly follow a gravitational orbit around their central point of *Gravity* (Chapter 9), as if the *Mono-Bits* themselves hold *Content*. In fact, this *Content* is represented by the orbit-shaped curving of a *Whereabouts* gridline. In general, we can indeed use physical equations (here: Newtonian equations) as if *Content* truly exists. In reality one is dealing with *Whereabouts* grid distortions that represent a deficit.

When two equal masses *m* keep each other in a stable gravitational orbit, at a mutual *distance D*, the gravitational attracting force F_G matches the centripetal force F_{CP}:

$$\boldsymbol{F_G = G.\frac{m^2}{D^2} \equiv F_{CP} = \frac{2.m.v^2}{D}} \tag{12.7}$$

Thus, for a stable gravitational orbit, the orbit *velocity* must equal:

$$\mathbf{v} = \sqrt{\frac{\boldsymbol{G.m}}{\boldsymbol{2.D}}} \tag{12.8}$$

The *mass m* of an orbiting *Mono-Bit* (based on $E = m.c^2 = h.\upsilon.S_{(nat)}$) equals:

$$m_{bit} = \frac{h.\upsilon.S_{(nat)}}{c^2} = \frac{h}{c^2} \times \frac{c}{\pi.D} \times S_{(nat)}$$

Or:

$$\boldsymbol{m_{Mono-Bit} = \frac{h.S_{nat}}{\pi.c.D}} \tag{12.9}$$

We can substitute (12.9) into (12.8):

$$\mathbf{v} = \sqrt{\frac{\boldsymbol{G.m_{bit}}}{\boldsymbol{2.D}}} = \sqrt{\frac{\boldsymbol{G.h.S_{(nat)}}}{\boldsymbol{2.\pi.D^2.c}}} \tag{12.10}$$

The orbit *velocity* of *Mono-Bits* equals '*c*'. If we substitute that in (12.10) the result is:

$$c = \sqrt{\frac{G.h.S_{(nat)}}{2.\pi.D^2.c}} \qquad (12.11)$$

From this we derive a constant orbit diameter *D*:

$$D = \sqrt{\frac{G.\hbar.S_{(nat)}}{c^3}} = \sqrt{\frac{G.\hbar.}{c^3}} \times \sqrt{S_{(nat)}} \qquad (12.12)$$

We can convert equation (12.12) to the *Crenel Physics* model, whereby *c=1* and for the *Entropy-Atom* $S_{(nat)}=ln(4)$…

$$D_{(Crenel)} = \sqrt{G_{cp} \times h_{cp}} \times \sqrt{\frac{\ln(4)}{2.\pi}}$$

…which can be further simplified to:

$$D_{(Crenel)} = \sqrt{G_{cp} \times h_{cp}} \times \sqrt{\frac{\ln(2)}{\pi}} \qquad (12.13)$$

Substituting the respective *Crenel Physics* values for G_{cp} and h_{cp} gives:

$$D_{(Crenel)} = \sqrt{\frac{\ln(2)}{\pi}}\ (Crenel) \qquad (12.14)$$

= 0.4697 *Crenel*

Equation (12.14) quantifies the local diameter of a stable gravitational orbiting system involving two *Mono-Bits*. If both *Mono-Bits* are (from a local perspective) orbiting at this universally equal distance, the local system is stable at any orbiting velocity: as the orbiting velocity goes up, so does the Planck-based *Content* per *Mono-Bit*. Per Newton the gravitational force between both Mono-Bits then grows to the second power, as the centripetal force is growing to the second power. Hence, a change in orbit velocity does not break orbit stability.

From a remote perspective however, we see the string following some orbit at light velocity *c*. As the curving of this wider orbit sharpens, we see:

1. A *Whereabouts* gridline shorten proportionally.
2. An orbiting frequency increase proportionally.

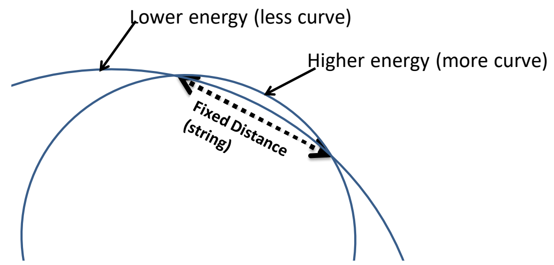

Fig.12.4: The Chord Length of all *Entropy-Atoms* is constant

The remotely felt duration of the afore mentioned spike in gravity would remain constant (as the duration of a light flash from a lighthouse). However, the remotely observed frequency would increase proportionally, as the wider orbit tightens.

Although this will appear so within a 3-dimensional space, in essence the *Entropy-Atom* is a 1-dimensional object that, with equal probability, can be oriented in any spatial direction without impacting our observations. As we may turn a lighthouse tower axis towards any direction, without impact on the light flashes we would receive from it.

g) The heaviest possible Entropy Atom

Equation (12.14) also defines the smallest possible orbit diameter, and thereby the maximum orbit *frequency* for an *Entropy Atom*. Per this equation the smallest possible orbit path length equals:

$$\textit{Shortest Orbit path length} = \pi.D = \sqrt{\pi.ln(2)} \qquad (12.15)$$

= 1.4757 *Crenel*

With light velocity c_{CP}=1 this corresponds to a maximum *frequency* of:

$$Frequency_{(max)} = \frac{1}{\sqrt{\pi.ln(2)}} \qquad (12.16)$$

= 0.6777 $Crenel^{-1}$ = 0.6777 *Packages*

Per *Crenel Physics* 1 *Package* corresponds to 7.4001E42 *Hz* (see Equation 1.11), so that in metric *UoM's* we find a maximum *frequency*:

$F_{(max)}$ = 0.6777 (*Package*) x 7.4001E42 *Hz*
= 5.0148E42 *Hz*
= 5.0148E30 *THz*

This value corresponds to 2.072E25 *keV*, which in turn equals 230.5 GeV/c^2.

CERN found with high probability the lightest version of the Higgs boson at 125.3 (± 0.6) GeV/c^2. Thus, the *Entropy Atom* can exceed that by a factor of almost 2.

Also, per standard model the heaviest possible Higgs boson should not exceed 1000 GeV/c^2. Therefore, the here found maximum possible *energy* contained within an *Entropy Atom* is within this constraint.

The Relationship between *nat*, *pi* and *ln(2)*

This manuscript addressed the conservation principle's bottom line. *Content* and *Whereabouts* were found related to one another (Chapter 1): the product of their *UoM's* was found to equal Planck's constant. The ratio thereof was found to equal the gravitational constant.

But how about the mathematical constants that we used to address *Information*, the third physical property within the *Crenel Physics* model? We only used three thereof (Chapter 4):

- ✓ the *nat* (for resolving *quantitative* uncertainty),
- ✓ the *bit* (for resolving *state* uncertainty),
- ✓ π (for linking *frequency* to *Whereabouts* coordinates).

Shouldn't we then expect a relationship between these three *UoM's* as well?

We already found that the *bit* is related to the *nat* via a conversion factor *ln(2)*:

$$1\ bit = \frac{1}{ln\ (2)} nat$$

But how does π fit in? Is there a relationship between the *bit* and π (or between *ln(2)* and π)?

To answer this question, consider the following function ***F(x)***:

$$\boldsymbol{F(x) = x^2 \times \left\{\sum_{n=0}^{\infty} \frac{(-1)^n}{(n.x+1)}\right\}}$$

As it turns out, at *x=1* (or more accurately*: x= 1 nat*) the value of ***F(x)*** equals *ln(2)*:

$$\boldsymbol{F(1) = ln(2) = \sum_{n=0}^{\infty} \frac{(-1)^n}{(n+1)}}$$

And for *x=2* the value of ***F(x)*** equals π:

$$\boldsymbol{F(2) = \pi = 4 \times \left\{\sum_{n=0}^{\infty} \frac{(-1)^n}{(2.n+1)}\right\}}$$

The above given function ***F(x)*** thus indeed mutually relates the three mathematical constants that we utilized. However, a physical explanation for this relationship was not identified.

References

[1] A.D. Kirwan Jr. / Intrinsic Photon Entropy? The Darkside of Light. International Journal of Engineering Science 42 (2004) 725–734

[2] An ‘improved cold atom’ measurement by Rosi et al., published in 2014

[3] https://en.wikipedia.org/wiki/Gravitational_redshift

[4] https://en.wikipedia.org/wiki/Planck_units

[5] https://en.wikipedia.org/wiki/Information

[6] https://en.wikipedia.org/wiki/Laws_of_thermodynamics

[7] https://en.wikipedia.org/wiki/Black-body_radiation

[8] https://en.wikipedia.org/wiki/Pound–Rebka_experiment