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:

\[ E = mc^2 \]

‘\( E \)’ 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:

\[ \left( \frac{c(m/s)}{kg} \right)^2 \equiv \frac{J}{kg} \]

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:

\[ c = 299,792,458 \text{ m/s} \]

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

\[ \sqrt{J/kg} \equiv 299,792,458 \text{ m/s} \]

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 \( E = mc^2 \) 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 \( E = mc^2 \) 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 \( \pi \), \( e \) and the \( \textit{bit} \), 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 Crelen Physics

For clarity, we will refer to our intended streamlined system of UoM’s as Crelen 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 \( E = m \cdot c^2 \) 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 Crelen 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 (e.g. 1 kilogram ≠ 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 \( E = m \cdot c^2 \). (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:

\[
c_{CP} \equiv 1
\]

(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 \( c_{\text{CP}} \). 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 corresponds 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).

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 \( C^4 \).**

Based on Newton’s laws, force is equal to mass times acceleration (\( F = m \cdot a \)). In Metric Physics, force \( F \) is measured in \( \text{kg} \cdot \text{m} / \text{s}^2 \). 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:

\[
F = G \cdot \frac{M_1 M_2}{d^2}
\]

We extract \( G \):

\[
G = \frac{F \cdot d^2}{M_1 M_2}
\]

In the above we substitute the Crenel Physics \( UoM \)'s for ‘\( F \)’, ‘\( d \)’ and ‘\( M \)’:

\[
G = \frac{P \cdot C^2}{P \cdot P} = \frac{C}{P}
\]

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

\[
G_{CP} \equiv 1 \cdot \frac{C}{P}
\]

---

Fig. 1.1: Crenels on Top of a Castle Wall

\[1.2\]
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...

$$E = h \cdot v$$

...we extract $h$:

$$h = \frac{E}{v}$$

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:

$$h_{CP} \equiv 1 \cdot C \cdot P$$

**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 $c$:

$$1 \text{ (dimensionless)} = c(m.s^{-1})$$

For Planck’s constant $h$:

$$1 \ P \cdot C = h(N.m.s)$$

For the gravitational constant $G$:

$$1 \ C/p = G(N.m^2.kg^{-2})$$

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:

$$1 \ P \cdot C = h \cdot c(N.m^2)$$

**Preparation step 3:**

Per Einstein’s $E = m \cdot c^2$, 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$^{-2}$):

$$1 \ C/p = G \cdot c^{-4}(N.m^2.N^{-2}.m^{-2})$$

or:

$$1 \ C/p = G \cdot c^{-4}(N^{-1})$$

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

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

Or (by taking the square root):

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

$= 4.9033 \times 10^9 \ J$
Leveraging Boltzmann, Einstein, Planck

From here onwards some other conversion factors can be derived:

Because 1 Joule equals \( c^2 \) kg:

\[
1 \text{ Package} = \sqrt{\frac{h c}{G}} \text{ (kilograms)} \quad 1.10
\]

\[
= 5.4557 \times 10^{-8} \text{ kg}
\]

Based on Planck’s \( E = h \nu \), equation (1.9) can likewise be converted to frequency (in \( s^{-1} \)):

\[
1 \text{ Package} = \sqrt[5]{\frac{h c^5}{G}} \times \frac{1}{\hbar} \text{ (s)} = \sqrt[5]{\frac{c^5}{\hbar G}} \text{ (s)} \quad 1.11
\]

Or:

\[
1 \text{ Package} = \left( \frac{c^5}{\hbar G} \right) \text{ (Hertz)}
\]

\[
= 7.4001 \times 10^{42} \text{ Hz}
\]

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):

\[c^2 = \frac{h G}{c^3} \text{ (meter}^2\text{)}\]

or:

\[
1 \text{ Crenel} = \sqrt[5]{\frac{h G}{c^3}} \text{ (meter)} \quad 1.12
\]

\[
= 4.0512 \times 10^{-39} \text{ m}
\]

And because one meter corresponds to \( c^4 \) seconds:

\[
\text{Crenel} = \sqrt[5]{\frac{h G}{c^3}} \text{ (seconds)} \quad 1.13
\]

\[
= 1.3513 \times 10^{-43} \text{ s}
\]

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:

\[
1 \text{ UoM for Temperature} = \frac{\text{UoM for Energy}}{k_B}
\]

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:

\[
1^0 T_{CP} = \left( \frac{h c^5}{G (k_B / k)} \right)^{\pi} \text{ (Kelvin)} \quad 1.14
\]

\[
= 3.5515 \times 10^{32} \text{ K}
\]

Equations (1.9) through (1.14) show resemblance with the well-known ‘Planck units’, albeit that the above equations hold Planck’s constant ‘\( \hbar’\), whereas the ‘Planck units’ hold the reduced Planck constant ‘\( h/2.\pi’ \) (symbol: ‘\( \hbar’\’). Had for Planck’s equation \( E = h \nu \) 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:

\[
1 \ P = \sqrt{\frac{h_{cp}}{G_{cp}}} \quad (Energie) \quad 1.15
\]

\[
1 \ P = \sqrt{\frac{h_{cp}}{G_{cp}}} \quad (Mass) \quad 1.16
\]

\[
1 \ P = \frac{1}{\sqrt{h_{cp} \cdot G_{cp}}} \quad (Frequency) \quad 1.17
\]

\[
1 \ C = \sqrt{h_{cp} \cdot G_{cp}} \quad (Distance) \quad 1.18
\]

\[
1 \ C = \sqrt{h_{cp} \cdot G_{cp}} \quad (Time) \quad 1.19
\]

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 9.1094x10^{-31} kg.

Because one mass UoM in Crenel Physics equals 5.4557x10^{-8} kg (see equation (1.10)), an electron therefore contains

\[
\frac{9.1094 \times 10^{-31} \text{kg}}{5.4557 \times 10^{-8} \text{kg}} = 1.6697 \times 10^{-23} \text{ Packages}
\]

...when measured in the mass Appearance.

b) Energy

Per Einstein’s equation \( E = mc^2 \), we find the electron to contain 8.1871x10^{-14} J of energy.

Because one energy UoM in Crenel Physics equals 4.9033x10^9 J (see equation (1.9)), an electron therefore contains

\[
\frac{8.1871 \times 10^{-14} \text{J}}{4.9033 \times 10^9 \text{J}} = 1.6697 \times 10^{-23} \text{ Packages}
\]

...when measured in the energy Appearance.

c) Frequency

Per Planck’s equation \( E = h \nu \), the electron’s Content can also be represented as a frequency of 1.2356x10^{20} Hz.

Because one frequency UoM in Crenel Physics equals 7.4001x10^{42} Hz (see equation (1.11)), an electron therefore contains

\[
\frac{1.2356 \times 10^{20} \text{Hz}}{7.4001 \times 10^{42} \text{Hz}} = 1.6697 \times 10^{-23} \text{ Packages}
\]

...when measured in the frequency Appearance.

d) Temperature

Perhaps less obvious is the embedding of a temperature UoM.

By using the general equation...

\[
T = \frac{h}{k_B |\nu|} \times |\nu|
\]

...we can convert an electron’s frequency into a temperature. This gives a value of 5.9299x10^9 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 3.5515x10^{32} K (see equation (1.14), an electron therefore contains...

\[
\frac{5.9299 \times 10^9 \text{K}}{3.5515 \times 10^{32} \text{K}} = 1.6697 \times 10^{-23} \text{ Packages}
\]

...when measured in the temperature Appearance.

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

1 electron = 1.6697x10^{-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.
\textbf{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\textsuperscript{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).

\textbf{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:
   \[ \sqrt{\frac{h_{cp}}{G_{cp}}} \]

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:

\begin{itemize}
  \item ✔ Applying the conversion procedure twice results in the original value, regardless of whether one starts with the Package or with the Crenel.
  \item ✔ Applying the conversion procedure twice has the same impact as a multiplication with dimensionless ‘1’.
\end{itemize}

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

\textit{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:

\textbf{(14) Content (in Packages) is equal to inverted Whereabouts (in Crenel)}

And vice versa:

\textbf{(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’? Is Planck’s constant over dimensioned when we say it is equal to \(PC\) (instead of 1)?

There is a physical argument to not follow this mathematical logic. When we refer to the product ‘\(PC\)’, we refer to Planck’s constant which is in fact the ‘inner product’ (also referred to as ‘scalar product’) ‘\(PC\)’ of two physical properties ‘\(P\)’ and ‘\(C\)’ respectively. This inner product ‘\(PC\)’ 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.
(4) How Boltzmann Enhances Planck and Explains Heisenberg

Let’s start by reviewing Boltzmann’s theory.

In his equation:

\[
S = k_B \cdot \ln (w)
\]

\[S = \text{Entropy}\]

We will detail the meaning of *Entropy* later.

\[k_B = \text{Boltzmann’s universal natural constant}\]

\[w = \text{Number of states in which a system can be found, where the following thereby applies:}\]

- **✓ 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.

- **✓ 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 Hz/K and J/K, with values for these examples as follows:

\[
\begin{align*}
k_{B(na)} &= 1 \quad \text{nat} \\
k_{B(bi)} &= 1.442695... \quad \text{bit} \\
k_{B(Hz/K)} &= 2.0836618... \times 10^9 \text{Hz/K} \\
k_{B(J/K)} &= 1.3806488... \times 10^{-23} \text{J/K}
\end{align*}
\]

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 \(\pi\), 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’. 

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12
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 (1x2^3)+(1x2^2)+(0x2^1)+(1x2^0) = 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.
Leveraging Boltzmann, Einstein, Planck

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 = \( \sqrt{\frac{h \cdot c}{6}} \) (kilograms)\( \approx \)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 (‘wobs’).

In the case of a single State Information Building Block, within equation (4.1) the term:
\[ \ln(w) = \ln(w_{obs}) = \ln(1) = 0 \]
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 nature’s 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 \( \geq 1 \).

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 \( S = k_B \cdot \ln(w) \), 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:

\[ S_{(bit)} = n \ (bits) \]

4.2

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

\[ S_{(bit)} = k_B^{(bit)} \cdot \ln(2^n) = k_B^{(bit)} \cdot n \cdot \ln(2) \]

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 ‘\( k_B^{(bit)} \cdot \ln(2) \)’ in equation (4.3) matches the numerical (=quantitative) value ‘1’:

\[ 1 = k_B^{(bit)} \cdot \ln(2) \]

The term ‘\( k_B^{(bit)} \cdot \ln(2) \)’ 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:

\[ 1 \text{ nat} = k_B(\text{bit}). \ln(2) \]

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:

\[ 1 \text{ nat} = k_B(\text{digit}). \ln(10). \]

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:

\[ h_{CP} \equiv 1 \text{ C. P} \]

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:

\[ h_{PI} \equiv 1 \text{ P. I} \]

And:

\[ h_{CI} \equiv 1 \text{ C. I} \]

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-kgs.
   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…

\[ k_B(\text{nat}) \equiv k_B(\text{bit}) \equiv k_B(\frac{h_z}{k}) \equiv k_B(\frac{I}{R}) \]

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

We already addressed the conversion factor (\( \ln(2) \)) between the two given microscopic versions \( k_B(\text{nat}) \) and \( k_B(\text{bit}) \). 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 \textit{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 \textit{UoM}s, any ratio between any two \textit{UoM}s of universal natural constants then must also be universally equal.

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

\[
\frac{J}{Hz} = \frac{1}{\text{second}^{-1}} = \text{J. s.}
\]

\textit{Metric Physics} typically expresses Planck’s constant \( h \) in J.s:

\[
h = 6.62607015 \ldots \times 10^{-34} \text{ J.s.}
\]

The consistency of this value can be verified within the \textit{Metric Physics} system where ‘\( h \)’ then must equal \( k_B(J/K)/k_B(Hz/K) \):

\[
(6.62607015 \ldots \times 10^{-34} \text{ J.s})
\]

\[
= (1.3806488 \ldots \times 10^{-23} \text{ J/K})
\]

\[
\div (2.0836618 \ldots \times 10^{10} \text{ Hz/K})
\]

The above holds true as expected, so that we found Planck’s constant \( h \) to represent the conversion factor at hand: \( k_B(J/K) = h \). \( k_B(Hz/K) \).

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

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

As mentioned in Chapter 1, \textit{Metric Physics} defines the \textit{UoM} for temperature as follows:

\[
1 \text{UoM (Temp.)} = \frac{\text{UoM (Energy)}}{k_B} \quad 4.7
\]

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

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

\[
(39) \text{To any version of Boltzmann’s constant, one can associate an Appearance for Content which then must lead to the same measure for temperature.}
\]

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 \textit{frequency} to be an \textit{Appearance of Content}. Based on the above generalization we can now alternatively define the \textit{UoM} for temperature as:

\[
1 \text{UoM (Temp.)} = \frac{\text{UoM (Frequency)}}{k_B} \quad 4.8
\]

\textit{Metric Physics} expresses \textit{frequency} in \textit{Hertz}. Here again we must ensure dimensional integrity, in this instance by using the \( k_B(Hz/K) \) version of Boltzmann’s constant.

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

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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:

\[
1 K = \frac{\text{nat}.K}{k_B(\text{nat})}
\]

And for \(k_B = 1\) bit:

\[
1 K = \frac{\text{bit}.K}{k_B(\text{bit})}
\]

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 \(k_B(\text{nat}) = 1\)).

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:

\[
1^0 T_{CP} = \frac{\text{Package}}{k_B}
\]

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:

\[
1^0 T_{CP} = \frac{\hbar c^5}{\sqrt{G (k_B J/K)^2}} \text{ (Kelvin)} \tag{4.12}
\]

\[
= 3.5515 \times 10^{32} K
\]

Again, this UoM resembles a ‘Planck Unit’ (here: for temperature). As before, we see ‘\(\hbar\)’ instead of ‘\(h\)’ 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 \(k_B(\text{nat})\) to \(k_B(\text{Hz/K})\). To find the conversion factor we divide the Crenel Physics conversion factor from Package to Hz per equation (1.11)...

\[
1 \text{ Package} = \frac{\sqrt{\frac{c^5}{\hbar G}}}{\text{(Hertz)}}
\]

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

The result indeed equals the macroscopic value for \(k_B(\text{Hz/K})\) as found in Metric Physics:

\[
1(\text{nat}) \equiv \frac{\sqrt{\frac{c^5}{\hbar G}}}{\sqrt{\frac{c^5}{\hbar G}}} = \frac{7.4001 \times 10^{52} \text{ Hz}}{3.5515 \times 10^{32} K} = 2.08366 \times 10^{10} (\text{Hz/K})
\]

\[
= k_B(\text{Hz/K})
\]

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)...

\[
1 \text{ Package} = \frac{\hbar c^5}{G} \text{ (Joules)}
\]

\[
= 4.9033 \times 10^9 J
\]
Leveraging Boltzmann, Einstein, Planck

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

$$1(\text{nat}) = \frac{\sqrt{\frac{\hbar e^2}{C}}} {\sqrt[4]{\frac{G^2}{k^2}}}$$

$$= \frac{4.9033 \times 10^9 J}{3.5515 \times 10^{32} K}$$

$$= 1.3806 \times 10^{-23} (J/K)$$

$$= k_B(J/K)$$

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:

- $\text{Content}(J) = T(K) \times S(J/K)$
- $\text{Content}(Hz) = T(K) \times S(Hz/K)$
- $\text{Content}(\text{bit. K}) = T(K) \times S(\text{bit})$
- $\text{Content}(\text{nat. K}) = T(K) \times S(\text{nat})$

4.15

4.16

4.17

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...

$$\frac{k_B(J/K)}{\hbar}$$

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:

$$\frac{k_B(J/K)}{\hbar} \times T = v \quad \text{or} \quad T = \frac{\hbar}{k_B(J/K)} \times v$$

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)...

$$\frac{k_B(J/K)}{\hbar}$$

… we can ‘reverse engineer’ equation (4.18)...

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

4.21

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

$$\text{Content(nat. Hz)}$$

$$= \frac{k_B(J/K)}{\hbar} \times T(K) \times S(\text{nat})$$

4.22

Here per equation (4.20), the term...

$$\frac{k_B(J/K)}{\hbar} \times T(K)$$

… equals frequency ‘v’. We thus find:

$$\text{Content(nat. Hz)} = v \times S(\text{nat})$$

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 \( E = h.v \), the above \textbf{Content} (in nat.Hz) can be converted to \textbf{Content} (in J) by multiplying it with Planck’s constant. Equation (4.23) then converts to:

\[ \text{Content}(J) = h \times v \times S_{\text{nat}} \]

Or:

\[ E = h.v.S_{\text{nat}} \quad 4.24 \]

Equation (4.24) is an enhancement to Planck’s equation \( E = h.v \) (which applies to \textit{Photons} only) and is applicable to particles with any \textit{Entropy} value. In Chapter 5 we will explore this further.

We will refer to equation (4.24) as the ‘enhanced Planck equation’.

\textbf{i) Heisenberg}

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

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

\textbf{(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 ‘\textit{State Uncertainty}’ equal to \( 1/2 \)-\textit{bit} as, should the \textit{uncertainty} exceed \( 1/2 \) \textit{bit}, the observed state would then jump to another (closer) state option. This minimum \textit{state uncertainty} is universally equal.

This minimum \textit{uncertainty} is regardless the potential number of potential \textit{states} of a system. Therefore, it implies an ‘absolute \( 1/2 \)-\textit{nat quantitative uncertainty}’ applicable to any observation or measurement.

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

\textbf{(42) The errors in \textit{Content} and \textit{Whereabouts} are symmetrical because the product of \textit{Content} and \textit{Whereabouts} is constant.}

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

Per the \textit{Crenel Physics} model, the \textit{uncertainty principle} can now be formulated:

\textbf{(43) The observed product of a \textit{Content Appearance} and a \textit{Whereabouts Appearance} embeds a minimum \textit{state uncertainty} equal to \( 1/2 \) \textit{bit}, which corresponds to a minimum \textit{quantitative uncertainty} equal to \( 1/2 \) \textit{nat}.}

The \textit{uncertainty principle} per the \textit{Crenel Physics} model thus can be written as:

\[ \Delta P \Delta C = \frac{h_{CP}}{2} \quad 4.25 \]

This equation is the \textit{Crenel Physics} version of Heisenberg’s \textit{uncertainty principle}.

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

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(5) Photons

Photons meet Planck’s equation \(E = h \cdot v\).
As with any particle they must also meet the ‘enhanced Planck equation’ (4.24):
\[ E = h \cdot v \cdot S_{\text{nat}} \]

For the latter, the ‘intrinsic’ Entropy value \(S_{\text{nat}}\) 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…

\[ \text{Content}_{\text{nkat.K}} = T(K) \times S_{\text{nat}} \]

… and substitute 1 for nat, and 1 for \(S_{\text{nat}}\) to apply it to Photons:

\[ \text{Content}(K) = T(K) \]

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):

\[ \text{Content}_{\text{packages}} = T_{\text{CP}} \]

(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 ‘\(T_{\text{CP}}\)’ to the frequency Appearance.

Per equation (4.20) we then must multiply ‘\(T_{\text{CP}}\)’ with the Crenel Physics version of Planck’s constant ‘\(h_{\text{CP}}\)’, which as we saw has a value equal to 1 (recall that \(h_{\text{CP}} = 1 PC = 1\)), 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) to Content:

\[ \text{Content}_{\text{packages}} = T_{\text{CP}} = h_{\text{CP}} \cdot v_{\text{CP}} \]

The above matches Planck’s equation \(E = h \cdot v\), 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 \(E = h \cdot v\).

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

(45) Where Photons flow, Content flows and 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:

![Photon Emission Spectrum of a Blackbody](image)

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:

\[ n_{\text{emitted}} \geq n_{\text{absorbed}} \]  \hspace{1cm} 5.3

We use symbols \( E_{\text{avg-emitted}} \) and \( E_{\text{avg-absorbed}} \) 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:

\[ n_{\text{emitted}} \cdot E_{\text{avg-emitted}} = n_{\text{absorbed}} \cdot E_{\text{avg-absorbed}} \]  \hspace{1cm} 5.4

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

\[ E_{\text{avg-emitted}} \leq E_{\text{avg-absorbed}} \]  \hspace{1cm} 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 \( E_{\text{avg-absorbed}} \) toward an object. At thermal equilibrium, per equation (5.5), the average Photon energy as found within the emission spectrum

---

Fig. 5.1: Photon Emission Spectrum of a Blackbody
Credit: Wikipedia.
From this we conclude:

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 \( n_{\text{absorbed}} \) for the blackbody.
2. The light frequency \( \nu \) which sets the value of \( E_{\text{absorbed}} \) for the Photons to be absorbed by the blackbody.

The blackbody thus is subject to a heat influx:

\[
\text{heat}_{\text{in}} = n_{\text{absorbed}} \times E_{\text{absorbed}}
\]  

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 \( E_{\text{absorbed}} \)) while proportionally increasing the intensity (and thereby \( n_{\text{absorbed}} \)). Although this exchange does not impact the total incoming heat flow, it must ultimately throttle back the average frequency (and thereby \( E_{\text{avg-emitted}} \)) 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 \( E_{\text{avg-emitted}} \)) 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 vanished.

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 \( E = h \cdot v \), 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):

\[
E = h \cdot v \times S(nat)
\]

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

\[
2 \text{ bits} = 2 \ln(2) \text{ nat} = \ln(4) \text{ nat} = \ln(4).
\]

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

\[
\text{Content}(f) = h \times v \times \ln(4) \]

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

\[
\text{Content(nat.K)} = T(K) \times \ln(4)
\]

(for Entropy-Atoms)

For Entropy Atoms we can simplify equation (6.2):

\[
\text{Content(K)} = T(K) \times \ln(4)
\]

(for Entropy-Atoms)

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

\[
1^\circ T_{CP} = \frac{h c^5}{G(k_B l/K)}
\]

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

\[
\text{1 Content UoM} = \frac{h c^5}{G(k_B l/K)} \times \ln(4) = 4.9234 \times 10^{32}
\]

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

The Crenel Physics version of equation (6.4) is:

\[
1 P = \frac{h_{CP}}{G_{CP}} \times \frac{\ln(4)}{k_B \text{energy}}
\]

(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
In the difference can be reflected its value to exactly 1. 299,792,458 conditions velocity. As shortest possible pathing 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 \( \text{m/s} \). 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 \( \text{m/s} \). 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 \( \alpha \) 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 \( da \), 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 $299,792,458\text{m/s}$ 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 of 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 $299,792,458\text{m/s}$ 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:

\[
1 \ P = \frac{\hbar}{G_{cp}}
\]

This equation came forth from applying Planck’s equation \( E = h \cdot v \). 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 \( S = k_B \ln (v) \) into the Crenel Physics model, we derived the ‘enhanced Planck equation’ (4.24):

\[
E = h \cdot v \cdot S_{(nat)}
\]

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:

\[
1 \ P = \frac{\hbar}{G_{cp}} \times \frac{\ln (4)}{k_B(T)}
\]

Thus, the Crenel Physics model produced two apparently different yardsticks for *Content*: one for the unobservable/unverifiable (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 \( \frac{\ln (4)}{k_B(T)} \) 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 \( \hbar_{cp} \), \( G_{cp} \) 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 \( 1 \ P \text{ackage} \). The multiplication of these two *Content* yardsticks then must equal \( 1 \ P \text{ackage}^2 \):

\[
\left\{ \frac{\hbar}{G_{cp}} \times \frac{\ln (4)}{k_B(T)} \right\} \times \left\{ \frac{\hbar}{G_{cp}} \right\} = 1 \ P\text{ackage}^2
\]

This requirement can be rewritten as:

\[
G_{cp} = \frac{\hbar}{k_B(T)} \times \ln (4) \times \text{Package}^{-2}
\]

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

\[
G_{cp} = \frac{\hbar}{k_B(T)} \times \ln (4) \times \frac{\text{Crenel}}{\text{Package}}
\]

(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:

\[ G_{CP} = \frac{h_{CP}}{k_B} \times \ln(2) \times \text{Package}^{-2} \]  

(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:

\[ F_{gCP}(ln P/\mathcal{C}) = G_{CP} \frac{\text{Content}(1) \times \text{Content}(2)}{\text{Package}^2} \]

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

\[ \text{Content} = \sum_{i}[r_{\text{embedded}} \times \ln(4)] - \text{(binding energy)} + \text{(heat)} + \text{(field energy)} + \text{(kinetic energy)} \]
earlier remark that Acceleration, being expressed in Crenel’s, 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 nature’s 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)...

\[ G_{CP} = \frac{\hbar c_p}{k_B(\ell / R)} \times \ln (4) \times \frac{\text{Crenel}}{\text{Package}} \]

… 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:

\[ G = \frac{h}{k_B(\ell / R)} \times \ln (4) \]

**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 \( G = 6.67384 \times 10^{-11} \).

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 \( 6.67191(99) \times 10^{-11} \text{N} \text{m}^2\text{kg}^{-2} \). This is approximately 0.03% below the commonly accepted value of \( 6.67384 \times 10^{-11} \).

Per the Crenel Physics model, a measurement of Gravity at low temperatures 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 Newton’s 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 Crenel¹ (the alternative measure for Content) equals –Crenel². From this we conclude that:

(60) Gravity is proportional to –Crenel², thus is proportional to -distance².

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 Crenel¹ in the first place (to find the gradient, and thus the force), this integration of
the differential obviously re-produces the original result: Crenel\(^4\).

Within the normalized *Crenel Physics* system of UoM’s, this Crenel\(^4\) 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 Physics* model- must then obviously hold within any system of UoM’s:

\[(61) \text{The energy gain of a descending photon in a gravitational field consists of two equal components: the (Newtonian) ‘potential energy gain’ and the (relativistic) ‘clock energy gain’}.
\]

**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...

\[ E = h \cdot v \cdot S_{(nat)} \]

…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 ‘v’ which did not exist before. Per enhanced Planck’s equation \( E = h \cdot v \cdot S_{(nat)} \), 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 \( E = h \cdot v \cdot S_{(nat)} \).

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 \( \Delta t_{local} \) needed for light to travel a distance, when multiplied with the velocity c, unambiguously delivers the length of that distance:

\[ \text{Distance}_{local} = \Delta t_{local} \cdot c \]  

With regards to our time measurement (\( \Delta t_{local} \)), 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 \( \Delta t_{local} \).
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 $\Delta t_{\text{local}}$, and multiply that with light velocity $c$ to find the distance. Thus:

\[
LOD = \Delta t_{\text{local}} \cdot c
\]

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:

\[LOD < ROD\]

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 $\Delta t_{\text{remote}}$ seconds. To ensure a hit with a narrow laser beam, we calculate the value of $\Delta t_{\text{remote}}$ 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)):

\[ \Delta t_{\text{remote}} = \frac{\text{ROD}}{c} \]  

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

\[ \text{BC} = v_{\text{orbit}} \cdot \Delta t_{\text{remote}} = v_{\text{orbit}} \cdot \frac{\text{ROD}}{c} \]  

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} \cdot ROD/c’ would be at its maximum:

\[ \frac{\text{ROD}}{c} = \frac{\text{ROD}}{c} \]  

The following figure shows this scenario:

![Diagram of orbit and angle relationships](image)

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:

\[ \left( \frac{\text{ROD}}{\pi \cdot \text{ROD}} \right) \times 2.\pi = 2 \text{ radians} \]

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 \((\pi - 2)\) radians.

The sin of half the angle \(\beta = \left( \frac{\pi - 2}{2} \right) \text{ radians} \) is equal to half of the ‘LOD’, divided by half the ‘ROD’. The minimum ratio LOD/ROD is then calculated as:

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

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

\[ \text{LOD} = \text{ROD} \times \cos(1) \]

Thus, when both objects orbit at light velocity ‘c’, we find 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° as indicated.
2. All three angles marked ‘α’ are equal.

Angle BXC (2.α) equals:

\[ 2.\alpha = \frac{v_{\text{orbit}} \cdot \text{ROD}/c}{\pi \cdot \text{ROD}} \times 2.\pi (\text{radians}) \]

\[ = \frac{2 \cdot v_{\text{orbit}}}{c} \text{ (radians)} \]

Angle BAC is half of that and thus equals: \(\frac{v_{\text{orbit}}}{c}\) radians.
From figure (9.5) it can be seen that $\cos(\alpha) = \text{LOD}/\text{ROD}$. Therefore:

$$\frac{\text{LOD}}{\text{ROD}} = \cos\left(\frac{v_{\text{orbit}}}{c}\right)$$

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

Or:

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

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 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 Crelé 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:

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

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

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 ($= \pi \cdot \text{LOD}$) relative to the longer meter and longer associated orbit path that we remotely observe ($= \pi \cdot \text{ROD}$).
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 $E = h \cdot v \cdot S_{(nat)}$ 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 $E = m \cdot c^2$.

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 $E = m \cdot c^2$ 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’](image)

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):

\[
\frac{ROD}{LOD} = \frac{1}{\cos(\text{orbit}_c)}
\]

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 our 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:

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):

\[
\frac{ROD}{LOD} = \frac{1}{\cos(\text{orbit}_c)}
\]

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 \( \alpha \).

Angle \( \alpha \) 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 \( \alpha \):

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:

$$R_R = \frac{ROD}{2}$$ 10.1

And we define $R_L$ as the reckoned Local orbit Radius:

$$R_L = \frac{LOD}{2}$$ 10.2

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

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

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

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

Per equation (9.8) we find:

$$LOD = \frac{2}{\cos\left(\frac{\nu_{\text{orbit}}}{c}\right) \cdot ROD}$$

Or:

$$R_L = \cos\left(\frac{\nu_{\text{orbit}}}{c}\right) \cdot R_R$$

We substitute this in equation (10.4):

$$\tan(\alpha_{LOD}) = \frac{\cos\left(\frac{\nu_{\text{orbit}}}{c}\right) \cdot R_R}{x}$$ 10.5

The angle $d\alpha$ then equals:

$$d\alpha = \tan^{-1}\left(\frac{R_R}{x}\right) - \tan^{-1}\left(\frac{\cos\left(\frac{\nu_{\text{orbit}}}{c}\right) \cdot R_R}{x}\right)$$ 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:

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

($x_R$ expressed in orbit radiiuses $R_R$)

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 $\nu_{\text{orbit}} = c$. 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 $\nu_{\text{orbit}} = c$)

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):
The following figure embeds the value thereof:

![Gradient da/dxR](image)

**Fig. 10.4: Gradient \( \frac{da}{dx_R} \)**

(as a function of distance \( x_R \) expressed in \( R_0 \)'s, based on an orbit velocity \( v_{\text{orbit}} = c \))

The gradient in the local Whereabouts pressure \( \frac{da}{dx_R} \) 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 \( R_B \) (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 towards 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:

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

This gives the following two values for distance \( x_R \):

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

If we assume \( v_{\text{orbit}} = c \) (as applicable to Entropy Atoms) the result is...

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

\[= 0.735052587 \ldots\]

...or, because \( R_K \) is the normalized \( UoM \) for distance:

\[x = \pm 0.735052587 \ldots \times R_R\]

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

\[da = \tan^{-1} \left( \frac{1}{x_R} \right) - \tan^{-1} \left( \frac{\cos \left( \frac{v_{\text{orbit}}}{c} \right)}{x_R} \right)\]

... is approximated by:

\[da_{\text{large}} \approx \frac{1}{x_R} \times \left( 1 - \cos \left( \frac{v_{\text{orbit}}}{c} \right) \right)\]

For large \( x_R \)

The following figure shows both curves, again based on an orbit velocity \( v_{\text{orbit}} = c \):
The Gradient in Whereabouts Pressure Equals the Gravitational Force

We reasoned that the gradient \( \frac{da}{dx} \) 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 \( v_{\text{orbit}} \) equals 1 and equation (10.6) can be written as:

\[
\frac{da}{dx} = \tan^{-1} \left( \frac{R_G}{x} \right) - \tan^{-1} \left( \cos(1) \frac{R_G}{x} \right)
\]

The gradient \( \frac{da}{dx} \) equals:

\[
\frac{da}{dx} \approx \frac{1 - \cos(\text{1})}{x^2}
\]

For very large values of distance \( x \), as well as for very small values of \( R \), the above equation is estimated by:

\[
\frac{da}{dx} \approx (1 - \cos(\text{1})) \times \frac{ROD}{x^2}
\]

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

\[
\text{Leveraging Boltzmann, Einstein, Planck}
\]
converts one-to-one into one unit of Content. To reflect this requirement, we write equation (10.12) as...

\[
\frac{d\alpha}{dx_{\text{large }x \text{ or small } R}} = \frac{\text{Content}_1}{x^2} \quad 10.13
\]

…so that Content\(_1\) represents the Content embedded within the orbiting system.

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

\[
F_G = G \times \frac{\text{Content}_1 \times \text{Content}_2}{x^2} \quad 10.14
\]

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 Content) distances.

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

\[
F_G = G \times \frac{d\alpha}{dx_{\text{large }x \text{ or small } R}} \times \text{Content}_2 \quad 10.15
\]

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).
- \(\frac{d\alpha}{dx_{\text{large }x \text{ or small } R}}\) is in \(\frac{P}{C^2}\) per equation (10.19).
- Content\(_2\) is in \(P\).

Substituting these dimensions into equation (10.15) gives:

\[
\frac{P}{C} = \frac{C}{P} \times \frac{P}{C^2} \times P = \frac{P}{C} \quad 10.16
\]

This confirms the dimensional integrity of equation (10.15).

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

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.
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 outcome 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 outcome 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 outgoing 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 589.9950 nm and 589.5924 nm respectively. As these values show, these spectral lines were measured with an accuracy of 7 digits so that their bandwidth is at most 0.00001% (corresponding to these 7 digits).

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.

![Probability Regions](image)

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*. 
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 ν equals 0. Per the enhanced Planck equation, $E = h \cdot v \cdot S_{\text{nat}}$, their Content thus is known without any uncertainty: it equals exactly 0.

Per Heisenberg’s uncertainty principle (see equation (4.25): $\Delta P \cdot \Delta C = \frac{h_{\text{gr}}}{2}$), 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:

$$L_0 = \infty$$  \[12.1\]

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.

$$L = 0$$  \[12.2\]

The solution for finding a different length between ‘locally’ and ‘relative to an observer’ is found in the Lorentz contraction:

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$  \[12.3\]

The Lorentz contraction quantifies the (shorter) observed object length $L$ relative to its local length $L_0$, pending its velocity ‘ν’ 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 ‘ν’ 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](image)

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 \( OX/v_{\text{interaction}} \), whereby the hypothetical interaction mechanism between Mono-Bit and sensor is presumed to travel at velocity ‘\( v_{\text{interaction}} \)’.

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.

\[ \text{b) A Course Change Reveals a Twin} \]

Assume that for some unknown reason, at location ‘O’, the Mono-Bit changes course with some angle \( d\alpha \). 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’](image)

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 \( E = h \cdot v \cdot S_{\text{nat}} \). 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 aforementioned 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 \( 90^\circ \).

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’ 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’ on the now redirected cone passes.

From this we conclude:
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:

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)...

$$E = h \cdot v \cdot S_{(\text{nat})}$$

…whereby for the Entropy-Atom, $S_{(\text{nat})} = \ln(4)$:

$$E_{EA} = h \cdot v_{EA} \cdot \ln(4) \quad \text{(12.4)}$$

The initial Photon’s energy equals:

$$E_{\text{Photon}} = h \cdot v_{\text{Photon}} \quad \text{(12.5)}$$

Based on the energy conservation principle and the consideration that the initial Mono-Bit did not contain energy, we demand:

$$E_{\text{Photon}} = E_{EA}$$

So that we find:

$$v_{EA} = \frac{v_{\text{Photon}}}{\ln(4)} \quad \text{(12.6)}$$

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?

\textit{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 $V = \text{light velocity } c$.

This comparison suggests that:

\textbf{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 $PC = \frac{1}{2}$. 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 $E = h \cdot v$.

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 $F_{CP}$:

$$F_G = G \frac{m^2}{D^2} \equiv F_{CP} = \frac{2m v^2}{D} \quad \text{(12.7)}$$

Thus, for a stable gravitational orbit, the orbit velocity must equal:

$$v = \sqrt{\frac{Gm}{2D}} \quad \text{(12.8)}$$

The *mass* $m$ of an orbiting *Mono-Bit* (based on $E = mc^2 = h \cdot v \cdot S_{(nat)}$) equals:

$$m_{bit} = \frac{h \cdot v \cdot S_{(nat)}}{c^2} = \frac{h}{c^2} \times \frac{v}{c} \times \frac{S_{(nat)}}{\pi \cdot D}$$

Or:

$$m_{Mono-Bit} = \frac{h \cdot S_{nat}}{\pi \cdot c \cdot D} \quad \text{(12.9)}$$

We can substitute (12.9) into (12.8):

$$v = \sqrt{\frac{G \cdot m_{bit}}{2D}} = \sqrt{\frac{G \cdot h \cdot S_{(nat)}}{2 \cdot \pi \cdot D^2 \cdot c}} \quad \text{(12.10)}$$
The orbit velocity of Mono-Bits equals ‘c’. If we substitute that in (12.10) the result is:

\[ c = \frac{G \cdot h \cdot S_{(nat)}}{2 \cdot \pi \cdot D^2 \cdot c} \]

From this we derive a constant orbit diameter D:

\[ D = \sqrt{\frac{G \cdot h \cdot S_{(nat)}}{c^3}} = \frac{G \cdot h}{c^3} \times \sqrt{S_{(nat)}} \]

We can convert equation (12.12) to the Crenel Physics model, whereby \( c = 1 \) and for the Entropy-Atom \( S_{(nat)} = \ln(4) \)…

\[ D_{(Crenel)} = \sqrt{G_{cp} \times h_{cp} \times \frac{\ln(4)}{2 \pi}} \]

…which can be further simplified to:

\[ D_{(Crenel)} = \sqrt{\frac{G_{cp} \times h_{cp} \times \ln(2)}{\pi}} \]

Substituting the respective Crenel Physics values for \( G_{cp} \) and \( h_{cp} \) gives:

\[ D_{(Crenel)} = \frac{\ln(2)}{\pi} \text{ (Crenel)} \]

\[ = 0.4697 \text{ Crenel} \]

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.

\textbf{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:

\[ \text{Shortest Orbit path length} = \pi \cdot D = \sqrt{\pi \cdot \ln(2)} \]

\[ = 1.4757 \text{ Crenel} \]

With light velocity \( c_{cp} = 1 \) this corresponds to a maximum frequency of:

\[ \text{Frequency}_{(max)} = \frac{1}{\pi \cdot \ln(2)} \]

\[ = 0.6777 \text{ Crenel}^1 = 0.6777 \text{ Packages} \]

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:
\[ F_{\text{max}} = 0.6777 \ (\text{Package}) \times 7.4001\text{E}42\ \text{Hz} \]
\[ = 5.0148\text{E}42\ \text{Hz} \]
\[ = 5.0148\text{E}30\ \text{THz} \]

This value corresponds to \(2.072\text{E}25\ \text{keV}\), which in turn equals \(230.5\ \text{GeV/c}^2\).

CERN found with high probability the lightest version of the Higgs boson at \(125.3 \pm 0.6\) \(\text{GeV/c}^2\). Thus, the \textit{Entropy Atom} can exceed that by a factor of almost 2.

Also, per standard model the heaviest possible Higgs boson should not exceed \(1000\ \text{GeV/c}^2\). Therefore, the here found maximum possible energy contained within an \textit{Entropy Atom} is within this constraint.
The Relationship between nat, π 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):

\[ F(x) = x^2 \times \left( \sum_{n=0}^{\infty} \frac{(-1)^n}{(n+1)x} \right) \]

As it turns out, at x=1 (or more accurately: x=1 nat) the value of F(x) equals ln(2):

\[ F(1) = \ln(2) = \sum_{n=0}^{\infty} \frac{(-1)^n}{(n+1)} \]

And for x=2 the value of F(x) equals π:

\[ F(2) = \pi = 4 \times \left( \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)} \right) \]

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


