Is gravity based on Boltzmann, Einstein and Planck?

Rethinking physics from scratch

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This is one of the many efforts to re-think physics from scratch. As scientists more and more work in specialized groups, it becomes increasingly relevant to periodically go through such effort.

1. Introduction into the task.

Re-thinking physics 'from scratch' requires stripping physics to the bones, and thereafter to throw these bones away. To apprehend, imagine how one would describe the world as perceived *before* one was born. Even 'time' would be undefined. But at some point one must have become aware of something ongoing. This happened when our sense organs started to produce signals, and our brain started to interpret and construct. 'Martians' (so to speak) may come up with a different description of the same world.

Physics also is based on mathematics. Mathematics in turn is based on our capability to apprehend abstract concepts (that is: concepts that can do without a physical sensor). For example the well-known number π (approximately 3.1416) comes forth from mathematics. It quantifies the ratio between a circle's circumference and its diameter, and it is equal for any circle size. Also, π is equal to all, therefore 'objective'. This π can be measured by using a rope and a yardstick. But such measurement is not nearly as relevant as the *procedure* that mathematicians delivered to extract the numerical value for π. Mathematics thus enhances the box that is encompassed by human sensors. Mathematics help to abstract, deduce, model, imagine, extrapolate, etcetera. Mathematical procedures thereby are non-relativistic: the procedures and results are equal to all (including the aforementioned 'Martians').

One is obliged to re-think from scratch again and again, in particular where science splits in diverse specialized and focused areas. The effort may glue seemingly different theories together, may make initially complicated concepts fall into place, may reveal or trigger new insights, etcetera. It may also ban theories to the periphery.

The author believes he achieved some of the above, at least at personal scale. One of the outcomes is a model named 'Crenel Physics', which makes the well-known objective Planck units of measurement easily understood (relative to their original whereabouts). Another outcome is the embedding of the gravitational constant into the model. If the latter is correct, the implications are paramount. Therefore the author seeks review. That's the purpose of this publication.

2. The scratch.

There is a universe. The difficulty is that –as consequence of our goal to start from scratch- we have no sensors to sense anything yet. Therefore we must start without any knowledge about this universe.

a) Internal investigation, the Crenel.

Let's temporarily personalize the situation by imagining that 'we' exist in some form. Even without sensors and incoming signals we imagine ourselves present, albeit as a 'black box' for now. We thereby find that 'events' (such as our thoughts) appear enrolling. Although we have no clue what a clock is, we nevertheless can now define the concept of 'time' to serve as reference to the internal enrolling sequence of events. This 'time' appears to elapse in a way that cannot be objectively quantified. But it does appear one-directional. That is: events appear not looping around, nor reverse in direction, nor do they appear as a fixed single –and thereby complete- snapshot. We therefore can define 'time' more accurately: we define 'history', the 'now', and also the 'future' in anticipation of what is yet to come. This positions every event that we know of in the past (which we named 'history').

> As an example: as two events we might have added 1+1=2, and we might have added 1+2=3. The first point is that these are two separate events. The second point is that we –as required here- did not need a sensor to perform these two tasks (we have no sensors yet). Thirdly, we did not and could not perform these two tasks (although very simple) simultaneously: we did it in sequence.

Despite not having a quantifiable time scale, we nevertheless can reconstruct which event came first, and which one thereafter. To achieve this, we chop 'history' into sequential parts. These parts do *not* need to be of equal duration: we do not yet know how we could measure or define the duration of a chop of time anyway. Let's give these chops of 'time' a name: 'Crenels'.

> **A 'Crenel' is a chop of 'time'.**
> **Or: 'time' is composed of a sequence of 'Crenels'.**
>
> Note: the name 'Crenel' is inspired by the crenels as found on top of castle walls: their shape can be associated with a

binary function. That is: a representation/visualisation of the simplest possible ongoing sequential process.

This time chopping creates the possibility to specify that a particular event took place within a certain timeframe, e.g. 3 Crenels back in history (which timeframe will soon be 4, 5, 6 etcetera Crenels ago). At this point we still have no definition for the magnitude of events that could be encompassed by one particular time chop… Nor could we objectively communicate about it to others. Others might also have defined 'Crenels' as time chops, but these are not equal to ours.

Mathematics lets us generally categorise/name the efforts that we are performing within our black box as 'information processing'. There is no relevancy yet in specifying what this information is about: in lack of sensors it must be fully abstract. But we can qualify the information itself as 'data'. Mathematically, any data can be represented by a series of 'bits'. The 'bit' is the smallest portion of information content. A 'bit' can have only two states, represented by e.g. a '1' and a '0'. Such 'bit' is a mathematical concept that –therefore- is non-relativistic and equal to all.

> **A 'bit' is the smallest possible chop of information. The 'bit' is a mathematical concept. Therefore it is a non-relativistic (equal to all observers) unit of measurement.**

'Information processing' is thus represented by at least one stream of bits that passes by as 'time' elapses. The processing may generate results that are represented by additional –responsive- streams of 'bits'.

> Note: since we can play a movie using a DVD, it is less difficult to accept that even an enrolling movie with surround sound originates from nothing but a stream of bits that were recorded on the DVD. The viewing is –ultimately- a binary process of firing signals between brain cells.

This brings us back to the Crenels. In order to be able to accurately reconstruct history, these chops of time must be short enough to detect each change in the information that we process in sequence, that is: to detect any change in the bit-stream.

> Our model also addressed the moment 'now'. There is no conceptual requirement that this 'now' is instantaneous (or: that it contains 0 Crenels), even though from a human perception the 'now' appears infinitesimally short. So far, the only requirement is that a 'Crenel' must be short enough to detect any change in information. Therefore it is sufficient that 'now' also is a chop of 'time' represented by 1 Crenel. Today's quantum mechanics plea for this option: it allows that –within 'now'- for example a 'quantum' can reside in different states, or: that these states appear 'simultaneously'.

In order to avoid confusion in terminology, from here onwards the model that we will further develop is named **'Crenel Physics'**. This is to differentiate from main stream physics, which will be referred to as **'Metric Physics'** (although it might not always be metric).

b) <u>The external, 'entropy-atoms'.</u>

To make contact (or: interact) with some external entity, our own black box needs sensors. Thereby, in lack of definition of properties that could be sensed, at this point a 'sensor' is nothing but a gateway through which information can enter or exit. And 'information' thereby is –as discussed- a data stream that is composed of bits. At this point it is not relevant what the information is about. One can imagine specialized gateways per type of information or per source of information.

In the bare minimum scenario such external entity information is represented by a 1 bit data stream. Or: the bandwidth of the data stream is 1 bit. Thus, the status of the external entity –at all times-only has two options that can be represented by a '1' or '0'.

> Note that a hypothetical broader bandwidth of a binary signal (e.g. 64 bits in parallel, as found in modern computers) is irrelevant to our search for the bare minimum: mathematically a broader bandwidth can be represented by a 1-bit signal (at a higher bit rate).

There is a general principle in physics, referred to as 'conservation law'. It prohibits an observable individual entity to *contain* just 1 bit (the terminology 'contain' as opposed to 'is represented by'). The conservation law would not allow a change of status within such individual entity: such change would require equal compensation, and there would be no other parameters that could change to compensate. Thus, in theory a 1-bit entity might exist as an individual entity, but the conservation law would prohibit it to change status. Therefore –inherently- it would be impossible to receive information from it. This makes it undetectable. A minimum detectable entity therefore must be of higher complexity. That requires containment of –at minimum- two bits. Thereby we can envision one bit 'flip', while the other then can 'flop' to compensate.

In the past, philosophers have thought about smallest –indivisible- objects. Although they did not yet know what these were, they named these 'atoms'. In the search thereafter, the mindset 'smallest' was associated with 'mass' or 'contained energy'. What we have at hand here however is a minimum *complexity* requirement: the conservation law demands that a smallest observable object must contain (or: its complexity must be represented by) two bits.

In Metric Physics, the *entropy* of a body (symbol 'S') is a measure for its complexity. This entropy can –amongst others- be expressed in 'bits', thus in an objective –universal- unit of measurement. Alternative Metric Physics units of measurement for 'entropy' are Joules/Kelvin, Hertz/Kelvin, etcetera. Thereby, both nominator and denominator in these units of measurement is sensor based and therefore relativistic. Note that the ratio's Joules/Kelvin and Hertz/Kelvin by implication of the above must be non-relativistic. Such is the bottom line of Boltzmann's constant being a universal natural constant. This will be discussed in more detail later. Furthermore, in Metric Physics the 'heat capacity' of a body also is expressed in J/K. Because per Boltzmann's constant J/K can be converted into 'bits' (a non-relativistic unit of measurement), the heat capacity of a body also is a non-relativistic property, as opposed to e.g. its 'mass', which value depends on its velocity relative to the observer.

In consideration of the above, the minimum detectable object will be named 'entropy-atom':

> **The 'entropy-atom' is the smallest detectible object (in terms of complexity). It has an entropy value 'S' of 2 'bits'.**

The 'entropy-atom' can be envisioned as two bits that are observed to be flip-flopping.

> **The postulation is that the universe is constructed of simplest possible entities, that is: of 'entropy-atoms'.**

c) <u>Temperature and the Package.</u>

In the Crenel Physics model we still did not define a time scale.

Instead we introduced un-quantified chops of 'time' named Crenels. Any 'time' interval is composed of an uninterrupted series of sequential Crenels.

Thereafter, the 'entropy-atom' was introduced. Such entropy-atom has the capability to produce a binary data stream. Such particular data stream has the basic shape '01010101010101… etcetera'. That is: a '1' is always followed by a '0', which in turn is always followed by a '1'. Therefore, the periodic sequence in itself does not contain information. The only information that can possibly be embedded in such a data stream is its pace: the number of Crenels that it takes to complete one 'period'. This sets the requirement for the duration of a Crenel: it must be short enough to accurately register any change in pace.

> **It is postulated here that such pace cannot be infinitely high.**

It cannot be proven that nature indeed has limitations. That's why this is postulated in Crenel Physics.

The next postulation is that:

> **Undisturbed physical processes are in sync with time measurement.**

Or: that there is a fixed relationship between the amount of elapsing time, and the changing of physical parameters (such as the pace of an entropy-atom). This postulation comes forth from the conservation law. In this particular case the postulation demands that –*in case of absence of influences*- the number of periods in the binary data stream per Crenel (time) remains as is. Or: that a change in this number would require a cause.

Based on the above we now introduce a physical property to an 'entropy-atom' in order to reflect the pace of the binary data stream that it produces. Thereby the Crenel is used as time basis (unit of measurement). This property will be named 'temperature' (symbol T_{CP}, whereby the subscript CP stands for the Crenel Physics version of 'temperature'):

> **'Temperature', symbol T_{CP} represents the number of periods per time interval of 1 Crenel.**

Consequently, the temperature has a minimum value of 0 Crenel^{-1}.

The current Crenel Physics model thereby links a –per postulation-presumed 'maximum frequency' to a 'shortest possible time interval' (the Crenel). The latter is based on the requirement that the Crenel must be short enough to register any change in pace. Consequently, the temperature cannot exceed a value of 1 Crenel^{-1}.

The above link between shortest time and smallest event reflects the essence of Planck's equation as found in Metric Physics:

$$\mathbb{E} = h.\upsilon \tag{2.1}$$

Albeit that this equation is based on a system of units of measurement (the Metric SI system) that is not available in Crenel Physics. The essence in the Crenel Physics model is Planck's non-relativistic connection between a 'time' scale (found in the frequency parameter '*v*') and a 'content' scale (found in the parameter energy '*E*'). In Crenel Physics there is no 'content' defined yet, but we did instead define an entity of minimum entropy (the entropy-atom) and a temperature scale ranging from 0 to 1.

In line with Planck, we can now introduce the new concept 'content' within Crenel Physics. Like the Crenel represents a 'time' dimension, this new concept of 'content' defines a second dimension. It will be named 'Package' and its unit of measurement is the Package.

> Note: the name 'Package' is inspired by its intuitive association with 'content'.

The definition of the Package is as follows:

> **An entropy-atom with a temperature of 1 Crenel^{-1} contains 1 Package of 'content'.**

This normalizes the relationship between the Crenel (the 'time' unit of measurement, symbol '*C*'), temperature and the Package (the 'content' unit of measurement, symbol '*P*'), where by implication of the above definition the Package is the reciprocal of the Crenel:

$$1\ Package = 1\ Crenel^{-1}. \tag{2.2}$$

Or, using the associated symbols:

$$P.C = 1 \tag{2.3}$$

Because such entropy-atom of 1 Package has the maximum temperature T_{CP} of 1 Crenel^{-1}, (which per equation (2.3) is equal to 1 Package) one Package also represents the maximum amount of content that an entropy-atom could possibly contain.

d) <u>Planck's constant.</u>

According to the definition of the Package, the content of an object is proportional to its temperature T_{CP} , or:

Content = (dimension conversion factor) x 'temperature'.

The unit of measurement (symbol 'UoM') for 'temperature' can therefore be defined as follows:

$$1\ UoM\ (T_{CP}) \equiv \frac{1\ UoM\ (Content)}{dimension\ conversion\ factor} \tag{2.4}$$

The unit of measurement of 'Content' is represented by the 'Package'.

$$1\ UoM\ (T_{CP}) \equiv \frac{1\ Package}{dimension\ conversion\ factor} \tag{2.5}$$

Because the temperature is expressed in Crenel^{-1}, the 'dimension conversion factor' in equation (2.5) equals one 'Package' x 'Crenel', or using the symbols thereof: '1P.C'.

This conversion factor is a 'natural constant' in the Crenel Physics model. It unambiguously connects 'time' to 'content', which is what Planck does in Metric Physics (see equation (2.1)). Therefore in Crenel Physics this natural constant will also be named 'Planck's constant' (symbol 'h_{CP}', whereby the subscript '*CP*' again stands for the Crenel Physics version thereof). Thus:

$$h_{CP} \equiv 1\ P.C \tag{2.6}$$

Equation (2.5) can then be written as:

$$1\ UoM\ (T_{CP}) \equiv \frac{1\ Package}{h_{CP}} \tag{2.7}$$

More in general, the above equation specifies the relationship between the temperature of an object, and the contained number of Packages therein:

$$T_{CP} \equiv \frac{Packages}{h_{CP}} \tag{2.8}$$

In retrospect, after introducing 'time' as a basic (un-quantified) initial dimension (to be expressed in Crenels) we introduced a second dimension 'content' (to be expressed in Packages). The general principle thereby was that this newly added dimension is to be associated with a 'dimension conversion factor' (here: Planck's constant). And such 'dimension conversion factor' is –it *must* be- a 'universal natural constant'. If not, the conversion between dimensions would not be a universal procedure (that is: a procedure with equal results to all), and thereby it would lead to conflicts in obeying the conservation law between various users.

This leads to a general insight when it comes to introducing new dimensions:

> **In order to introduce new dimensions into Crenel Physics, one requires an associated 'dimension conversion factor', which is generally referred to as: a 'universal natural constant'.**

3. A spatial universe.

In the Crenel Physics model, so far we have two dimensions: 'time' (measured in Crenel) and 'content' (measured in Packages). This is the starting point for enhancing the construction of our universe.

a) Distance, Einstein's constant.

We 'see' the universe as a 3-dimensional spatial space, in which each and every entity resides. The objectivity of this 'seeing' is questionable: is this driven by our human sensors? Would 'Martians' envision a likewise spatial space (so to speak)? For now, this question of objectivity is not relevant to the Crenel Physics model. It is sufficient to –more in general- accept that we need extra dimensions to relate physics to our observations. In the first place we need a dimension that allows us to model a familiar concept named 'distance'. This concept is related to 'time' measurement because we want to use 'distance' to specify 'velocity', yet another concept that we 'see'. Thereby, 'velocity' is the ratio of covered 'distance' per unit of elapsed 'time'. Thus, the first task is to introduce 'distance' as a new dimension into Crenel Physics and the next task is to review 'velocity' within this context.

> Note the difference between 'unit of measurement' and 'dimension'. E.g. in Metric Physics we need only one unit of measurement, the 'meter', for specifying the 3 dimensions in a 3-dimensional spatial world (e.g. X, Y and Z-coordinates). Thus, using just one single unit of measurement (e.g. the Crenel) one can construct many different dimensions.

To perform the task at hand, the general procedure was already addressed, and is repeated here:

> **In order to introduce new dimensions into Crenel Physics, one requires an associated 'dimension conversion factor', which is generally referred to as: a 'universal natural constant'.**

To introduce 'distance' into Crenel Physics, we execute the above procedure as follows (whereby symbol 'UoM' again stands for Unit of Measurement):

$$1\ UoM\ (Distance) = 1\ UoM\ (time) \times dimension\ conversion\ factor \tag{3.1}$$

The ‘dimension conversion factor’ thereby must be a universal constant. In this case the conversion factor will be named ‘Einstein’s constant’, symbol ‘c_{cp}’. The reason for associating here with Einstein and the velocity of light (through symbol ‘c’) is that equation (3.1) represents Einstein’s discovery that the velocity of light is a universal constant that relates ‘distance’ to ‘time’ in an unambiguous manner.

> Where Planck found an unambiguous relation between ‘time’ and ‘content’, Einstein found an unambiguous relation between ‘time’ and ‘distance’.

Equation (3.1) defines two separate dimensions that both use the Crenel as unit of measurement. In order to differentiate we will name the associated dimensional values ‘coordinates’ for which we will use the symbols $Crenel_T$ and $Crenel_D$. The subscripts ‘T’ and ‘D’ refer to ‘time’ and ‘Distance’ dimension respectively. Equation (3.1) can be written as:

$$Crenel_D \equiv Crenel_T \times c_{CP} \tag{3.2}$$

Within Crenel Physics we now need to specify the natural constant ‘c_{CP}’, both in terms of numerical value as well as in terms of unit of measurement. At this point –and in concept- we have total flexibility in doing so. However, before becoming too creative here, the aforementioned concept ‘velocity’ needs further exploration. The introduction of the $Crenel_T$ and $Crenel_D$ inherently delivered the specification of the unit of measurement for ‘velocity’:

$$UoM\ (velocity) = \frac{Crenel_D}{Crenel_T} \tag{3.3}$$

Per equation (3.2) the ratio at the right side of above equation is equal to ‘c_{CP}’. Therefore:

$$UoM\ (velocity) = c_{CP} \tag{3.4}$$

In other words: through its definition per equation (3.3), in Crenel Physics ‘velocity’ is a scalar multiplied by the universal constant ‘c_{CP}’.

The conservation law gives a requirement to what the concept ‘velocity’ really stands for. Per conservation law, ‘velocity’ is to be seen as the exchange between Crenels in their ‘time’ dimension towards Crenels in their ‘distance’ dimension. Thus, through ‘velocity’ (= this exchange) no Crenels can be gained or lost. The conservation

law -when applied to ‘velocity’- eliminates the flexibility for specifying ‘c_{CP}’: it must be a dimensionless 1.

$$c_{CP} \equiv 1 \tag{3.5}$$

> Note that through this definition, in Crenel Physics the observed velocity of an object is expressed as a fraction of light speed: ‘velocity’ has a dimensionless numerical value between 0 and 1.
> One cannot expect more than full exchange between Crenels in their ‘time’ dimension towards Crenels in their ‘distance’ dimension. Therefore, velocity has an objective maximum value (this is what Einstein discovered, albeit through a different route).

The conservation law does allow ‘velocity’ to be a relative property, subjective to the observer’s relative circumstances: without gain or loss of Crenels, different observers may find different velocity values between them, when monitoring one single object.

> Note: from here onwards, observations that are subject to observer’s circumstances (relative to the observed) will be named **‘appearances’.**

Where the units of measurement Crenel and Package are universally equal to all (thus not ‘appearances’), ‘velocity’ at the other hand is relative to the observer and therefore an ‘appearance’.

b) Gravity.

Per current Crenel Physics model the universe is constructed of entropy-atoms. Each entropy-atom thereby has gateways though which it receives data streams that originate from other entropy atoms.

If it were just that, there would be a conflict with the general conservation law. This law demands each incoming data stream to be compensated by a countermeasure of equal impact. It is this incoming data stream, and thereby the associated ‘content’ message that needs to be compensated by a countermeasure.

One way of modeling such countermeasure is that the incoming data stream –upon receipt at the gateway- is inversed and reflected. At the gateway this leads to a summation of two data streams which is constant signal in time, and thus without net information (or implication). The gateway thereby acts as some sort of mirror: at the internal gateway a mirror image of the external entropy-atom is residing. Thus, between an external entropy-atom and the internal gateway a well-defined form of 'handshaking' takes place at a certain pace. That pace is set by the external entropy-atom's temperature.

As a next step, imagine –for apprehension- a beam of light that is reflected by a mirror. Light consists of photons that have impulse. Thus, the mirror is pushed backwards by the light beam, based on the conservation law. What we have here however is a *data* stream that hits an entropy atom's gateway, where it is reflected. Now assume that this stream –like light- also contains something like impulse. It could not be real impulse, because a data stream only *represents* 'content', but it *contains* no 'content' like photons. Consequently the 'backward force' associated with an incoming data stream would *not* appear as a backward force: it appears as some other dimension of force, but proportional in terms of consequence.

> We already discussed conversion between various dimensions of the same underlying unit of measurement: 'velocity' represents a conversion between a 'time' and a 'distance' dimension, which both are expressed in the unit of measurement Crenel.

In this case, based on the conservation law, this consequential backward force dimension would still need to be compensated by a forward force, that is: an attracting force between the sending external entropy-atom and the receiving entropy atom. This consequential –forward- force of this handshaking will be named 'gravity'.

> **'Gravity' (symbol 'G_{CP}') is the countermeasure to the data handshaking process (that is composed of an incoming data stream from a remote entity and the reflection thereof).**

Thus the Crenel Physics model describes:

1. an 'action',
   which is the information stream that hits the gateway and that originates from some external entropy-atom, and,
2. a 'reaction',
   which originates at the gateway and produces the mirrored information stream that serves as countermeasure.

In combination the above action and reaction generate a 'force' at the gateway. This 'force' does however not appear in the dimension of 'force' (as we know it), but it appears in an alternate dimension.

3. Therefore, to compensate for the latter, a second countermeasure is required: it appears as an attracting force between the two entropy-atoms.

Because in their magnitude the aforementioned 'handshaking' and 'gravity' are equal (they just are different dimensions of information transfer) the term 'gravity' will be used to name the appearing consequence of a data stream hitting a gateway.

One can imagine experiments to verify 'gravity' as a consequence of a data stream.

> Consider two very small material objects. Now start a very high rate of data exchange between both objects. This should result in an extra gravitational attracting force.
>
> Take measures to reduce the data transfer rate between objects. This should result in apparent gravity beating effects. One possibility is the lowering of 'temperature'.
>
> Hit a target by a continuous laser beam. This should push the target backward. Now let the laser beam be intermitting on/off at a very high frequency, 50% on and 50% off. Modulate the frequency. The beam now contains information (about the modulation). Impulse laws would reduce the push-back force at the target by exactly 50%. The current model would predict a higher force reduction as a result of an attracting gravitational component.
>
> Etc.

The Crenel Physics model did not yet require the external entropy-atom to be positioned in terms of 'distance': we did not spatially pinpoint the external entropy-atom in order to describe the mechanism. It was sufficient to specify that the entropy-atom is 'external'.

c) <u>Gravity in space, the gravitational constant.</u>

In Crenel Physics, the handshaking takes place between an internal gateway and an external entropy-atom. Thereby the 'internal' was -for editorial reasons- personalized. Now that 'distance' and 'spatial space' have been introduced, we also can –as a remote observer-review the interaction between two entropy-atoms 'A' and 'B'.

Both entropy-atoms thereby have a gateway at which handshaking takes place. This handshaking is based on the individual 'temperature' of the other entropy-atom. Thus we are reviewing two separate handshaking paces 'A' and 'B' between two entropy-atoms 'A' and 'B'.

Let's review one of these: the handshaking that is induced by entropy-atom 'B' at entropy-atom 'A'. Because the model is spatial now, let's assume the initial distance between 'A' and 'B' is 1 Crenel. The question now is what the impact of 'distance' would be on the handshaking process. To explore this, assume the distance is increased from 1 to 2 Crenels. This is a change in a parameter. By conservation law this change needs to be compensated by some countermeasure. To get guidance in defining the required countermeasure, refer to equation (2.3):

$$P.C = 1$$

Although the above equation relates to the two different units of measurement Package and Crenel, it also gives guidance in how the conservation law can be obeyed in the case at hand: the increase in Crenels can be compensated by a proportional decrease in Package appearance. Therefore it can be concluded here, that –in lack of other parameters in the model- the impact of increasing the distance between 'A' and 'B' is to be compensated by cutting the incoming message proportionally. Or: in this example by cutting the apparent temperature in half. The normalization within Crenel Physics pays out here. The conservation law –when applied to each of the 2 individual handshaking processes- can thus be expressed as follows:

$$\frac{The\ observed\ temperature\ (in\ Packages)}{The\ observed\ mutual\ distance\ (in\ Crenels)} = constant \qquad (3.6)$$

The above relationship must be universal, applicable to all, because it relates two different dimensions to each other. Therefore the 'constant' in equation (3.6) must be a universal natural constant. To find it, the equation can be re-written as:

$$\frac{observed\ temperature\ (in\ Packages)}{D\ (in\ Crenels)} \times constant\ \equiv 1 \qquad (3.7)$$

Whereby symbol D stands for the observed distance, measured in Crenels. The 'constant' in equation (3.7) can be found by replacing the variables in the equation by their respective units of measurement. We will use symbol 'G_{CP}' for the 'constant' in the equation. This constant will be named: 'gravitational constant', whereby the subscript 'CP' refers to the Crenel Physics version thereof. This leads to the following:

$$\frac{1\ Package}{1\ Crenel} \times G_{CP}\ \equiv 1 \qquad (3.8)$$

Or:

$$G_{CP}\ \equiv 1\ \frac{Crenel}{Package}\ \equiv 1\ \frac{C}{P} \qquad (3.9)$$

Note that in Metric Physics the gravitational constant is associated with a 'force':

$$F_g = G.\frac{M_1.M_2}{R^2} \qquad (3.10)$$

Dimensional analyses (to be discussed later) will show that this equation –when transformed to Crenel Physics units of measurement- also demand the gravitational constant G to be expressed in C/P.

d) <u>Summary of natural constants.</u>

In summary, until here only two units of measurement were introduced into Crenel Physics: the Crenel and the Package. Based on these, the following three natural constants were defined:

Per equation (2.6) Planck's constant:

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

Per equation (3.5) Einstein's constant:

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

And per equation (3.9) the gravitational constant:

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

Both the inner product of Packages and Crenels as well as the ratio between Packages and Crenels have thus been addressed, normalized, and linked to natural constants.

4. A side-step to Metric Physics.

Let’s explore how Metric units of measurement are to be transposed into Crenel Physics units of measurement. The general rule thereby is that any property that can be ‘measured’ is downgraded to an ‘appearance’ in Crenel Physics. The term ‘appearance’ thereby expresses the fact that the numerical result of the measurement is subject to sensor circumstances relative to the monitored object. Or: the measurements are relativistic.

The table below lists some appearances in Metric Physics, and their Crenel Physics unit of measurement:

Appearance	Symbol	Metric unit of measurement	Crenel Physics unit of measurement
Mass	‘m’	Kg	P
Distance	‘d’	Meter	C
Energy	‘J’	Joule	P
Time	‘t’	Second	C
Velocity	‘v’	m/s	Dimensionless
Acceleration	‘a’	m/s^2	C^{-1}
Rotational speed	‘Ω’	rad/s	rad/C

Frequency	'υ'	s^{-1}	C^{-1}
Force	'F'	N(ewton)=kg.m/s^2	P/C

Table 4.1: Metric units of measurement ('appearances') and their Crenel Physics counterparts.

Crenel Physics shows only Crenel and Package as units of measurement. The conversion towards the Metric Physics 'appearances' requires natural constants (that are non–relativistic, equal to all). Through this requirement any conversion procedure leads to unambiguous –non-relativistic- results.

> Imagine that conversion procedures were not based on universal (non-relativistic) natural constants. As a consequence, between various users there would be differences in e.g. converting an apparent amount 'X' of Joules to an apparent amount 'Y' of kilograms, or between converting either of these into Packages. Consequently, the conservation law would be violated.

Natural constants therefore lie at the basis of any system of units of measurement in physics. Between Crenel Physics and any other system of units of measurement these natural constants must be equal, which leads to the following 3 equations:

$c_{cp} = c$ (4.1)
$h_{cp} = h$ (4.2)
$G_{cp} = G$ (4.3)

In the above three equations the subscript 'cp' refers to the Crenel Physics version of the natural constant. These constants are to be expressed in Crenel Physics units of measurement, whereas the right hand sides of the equations are to be expressed in the units of measurement in the alternate system.

When the alternate system is SI (as in Metric Physics), the three above equations -including their units of measurement- thus are as follows:

1 (dimensionless) = c (m.s^{-1}) (4.1a)

1 P.C = h (N.m.s) (4.2a)
1 C.P^{-1} = G (Nm^2kg^{-2}) (4.3a)

The above three equations make it possible to calculate objective conversion factors for the Crenel and the Package towards various Metric Physics 'appearances'.

In equation (4.2a) the symbol 's' in the unit of measurement can be replaced by 'c m' because in Metric Physics 1 second corresponds to 'c' meters:

1.P.C = h.c (N.m^2) (4.2c)

Based on Einstein's E=m.c^2, 1 kg corresponds to c^2 Joules or c^2 (N.m). In equation (4.3a) the kg^{-2} in the unit of measurement can therefore be replaced by: c^{-4} (N^{-2}.m^{-2}):

1 C.P^{-1} = G.c^{-4} (N.m^2.$N^{-2}$$m^{-2}$) = G.$c^{-4}$ (N^{-1}) (4.3c)

Dividing equation (5.2c) by equation (5.3c) gives:

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

Or:

$$1\,Package = \sqrt{\frac{h.c^5}{G}} \qquad \boldsymbol{Joule} \qquad (4.4)$$

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

$$1\,Package = \sqrt{\frac{h.c}{G}} \qquad \boldsymbol{kg} \qquad (4.5)$$

Because $\mathbb{E} = h.\upsilon$, equation (4.4) can be converted to frequency (in seconds^{-1}):

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

or:

$$1\ Package = \sqrt{\frac{c^5}{h.G}} \qquad \textbf{Hertz} \qquad (4.6)$$

Multiplying equation (4.2c) with equation (4.3c) gives:

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

Or:

$$1\ Crenel = \sqrt{\frac{h.G}{c^3}} \qquad \textbf{meter} \qquad (4.7)$$

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

$$1\ Crenel = \sqrt{\frac{h.G}{c^5}} \qquad \textbf{seconds} \qquad (4.8)$$

If one replaces Planck's constant '*h*' by the reduced Planck constant 'h/2.π' (for which symbol '$\hbar$' is used) all shown conversion factors are equal to the so called 'Planck units of measurement' (also called 'natural units of measurement'). Or: after such replacement the found conversion factors are respectively 'Planck energy', 'Planck mass', 'Planck angular frequency', 'Planck distance' and 'Planck time'.

The reason for finding '*h*' instead of '$\hbar$' in the above conversion factors is, that in Crenel Physics a full period in the binary information stream was used as frame of reference for defining the Package and 'temperature', see chapters (2.c) and (2d). The Package thus is associated with a 'frequency' (expressed in s^{-1} or Hertz), rather than with an 'angular frequency' (expressed in rad/s). Had been opted for the latter (which would be a valid option), all above conversion factors would exactly match the Planck units of measurement.

The reason for finding Planck units of measurement as conversion factors (apart from finding '*h*' instead of '$\hbar$') is that Crenel Physics did not normalize all natural constants to a dimensionless '1'. Instead,

the two dimensions 'when/where' (in Crenels) and 'content' (in Packages) were kept open, whereby their inner product was found to equal 1 (which happens to be the velocity of light).

In words, the basis for Crenel Physics can be summarized as follows:

> **When expressed in objective units of measurement, the inner product of the 'where/when' and the 'what' equals the 'velocity of light'.**

The above does not embed a new insight in physics (it has been worded in many ways). However, its whereabouts (as well as the whereabouts of Planck's units of measurement) are made more transparent by the Crenel Physics model.

From table (4.1) the dimensional soundness of the Metric Physics equation for gravitational force (equation (3.10))…

$$F_g = G.\frac{M_1.M_2}{R^2}$$

…can now be verified in Crenel Physics. Per table (4.1):

F_g	is expressed in P/C,
G_{CP}	is expressed in C/P,
$M_{1,2}$	are expressed in P,
R	is expressed in C.

When substituted in above equation, dimensions match.

5. Extending dimensions.

In the previous chapter conversion factors were calculated from Package and Crenel towards Metric units of measurement, see equations (4.4) to (4.8). Thereby:

Equation (4.4) converts Packages to Joules (=energy).
Equation (4.5) converts Packages to kg (= mass).
Equation (4.6) converts Packages to Hertz (= frequency= seconds^{-1})

According to the Crenel Physics model, these metric units of measurement (Joules, kg and Hertz) are not 'units of measurement': these are three different *dimensions* that all unambiguously are measured in the same unit of measurement (the Package). The associated conversion factors were found based on natural constants only, and therefore are non-relativistic (a requirement). The conversion factors show resemblance with the well-known Planck units of measurement.

In Crenel Physics we can now span the exact same three dimensions, where in all three the unit of measurement is the Package. Thereby we use the natural constants as found in Crenel Physics:

$$h_{CP} \equiv 1\ P.C \qquad (5.1)$$

$$c_{CP} \equiv 1 \qquad (5.2)$$

$$G_{CP} \equiv 1\ \frac{C}{P} \qquad (5.3)$$

We start by spanning an 'energy' dimension (for which we will use symbol E_{CP} as unit of measurement, subscript 'CP' thereby as usual stands for Crenel Physics, UoM stands for 'Unit of Measurement'). We thereby use equation (4.4) in which we can leave out the velocity of light c_{CP} because in Crenel Physics this value is equal to dimensionless 1. The conversion from Package to this 'energy' dimension then is:

$$1\ Package = \sqrt{\frac{h_{CP}}{G_{CP}}} \qquad (UoM = E_{CP}) \qquad (5.4)$$

Dimensional verification: by substituting the natural constants (equations (5.1) and (5.3)) into equation (5.4) it can be verified that the dimension of the right hand side of the equation indeed is equal to the Package, as required per dimension analyses.

Next we span a 'mass' dimension (symbol M_{CP}) in a likewise manner, now using equation (4.5):

$$1\ Package = \sqrt{\frac{h_{CP}}{G_{CP}}} \qquad (UoM = M_{CP}\ ) \qquad (5.5)$$

Obviously, there is no difference between the conversion factors towards both new dimensions 'energy' and 'mass'. The reason for that is that in Crenel Physics the velocity of light c was normalized to 1.

Things are different when we now span a 'frequency' dimension (symbol F_{CP}), based on equation (4.6):

$$1\ Package = \sqrt{\frac{1}{h_{CP}.G_{CP}}} \qquad (UoM = F_{CP}) \qquad (5.6)$$

Again, by substituting the natural constants (equations (5.1) and (5.3)) it can be verified that the dimension of the right hand side of the above equation indeed is equal to the Package, as required per dimension analyses.

Note that per chapter (2c) one Package also corresponds with one entropy-atom with a temperature of 1 Crenel^{-1}, see equation (2.7):

$$1\ Package = h_{CP} \times T_{CP} \qquad (5.7)$$

Therefore, besides the three aforementioned 'energy', 'mass' and 'frequency' dimensions that are inspired by known dimensions in Metric Physics, in Crenel Physics we also have a fourth dimension per equation (5.7). A rightful name for it would be '**information-temperature**', where the unit of measurement would be $ITemp_{CP}$.:

$$1\ Package = h_{CP} \times T_{CP} \qquad (UoM = ITemp_{CP}) \qquad (5.7a)$$

In the same manner we can review the two dimensions that were based on the Crenel:

Equation (4.7) converts Crenels to meters (=distance).
Equation (4.8) converts Crenels to seconds (=time).

Thus we span a 'distance' dimension (expressed in D_{CP}) for which the conversion factor is given by equation (4.7):

$$1\,Crenel = \sqrt{h_{CP}.G_{CP}} \qquad (UoM = D_{CP}) \qquad (5.8)$$

Dimensional verification: by substituting the natural constants (equations (5.1) and (5.3)) it can be verified that the dimension of the right hand side of the above equation indeed is equal to the Crenel, as required dimension analyses.

Finally a 'time' dimension is defined in Crenel Physics (symbol T_{CP}) based on equation (4.8):

$$1\,Crenel = \sqrt{h_{CP}.G_{CP}} \qquad (UoM = T_{CP}) \quad (5.9)$$

As was the case between 'mass' and 'energy' being based on an equal conversion factor (due to the velocity of light being 1 in Crenel Physics), this likewise is the case between the 'time' and the 'distance' dimension.

Thus, in summary, in Crenel Physics:

1. we defined four Package based dimensions, expressed in the units of measurement E_{CP}, M_{CP} , F_{CP} and T_{ITCP} (for Energy, Mass, Frequency and Information-Temperature). The respective conversion factors are given by equations (5.4), (5.5), (5.6) and (5.7a),
2. we defined two Crenel based dimensions, expressed in the units of measurement D_{CP} and T_{CP} (for Distance and Time). The respective conversion factors are given by equations (5.8) and (5.9).

Apart from the new Information-Temperature dimension, all others were based on dimensions as found in Metric Physics.

6. Boltzmann.

The physicist Boltzmann analyzed the implications of *microscopic* properties when applied to a large group of particles. Assume such group large enough to make the contribution of one single particle irrelevant from a statistical viewpoint. Such large groups are named **'ensembles'**. Ensembles have properties that are referred to as *macroscopic* (as opposed to *microscopic* properties). Boltzmann found that macroscopic properties are based on summations of underlying microscopic properties. He applied the conservation law to the ensemble.

> Boltzmann's finding –when formulated as above- might sound trivial. Note however that historically one was mostly limited to measuring macroscopic properties and therefore introduced a variety of macroscopic units of measurement such as 'temperature' and 'pressure'. At micro-scale such macroscopic properties lose their statistical context.

Boltzmann demonstrated unambiguous relations between macroscopic and microscopic properties. His theory embeds the physical property 'entropy' (symbol: 'S'). In order to find its value one needs –as we will see- an associated natural constant which was rightfully named Boltzmann's constant, symbol 'k_B'.

> In line with Boltzmann's theory we already used 'entropy' in Crenel Physics as a measure for 'complexity' at microscopic scale: the 'entropy-atom' has an entropy value of 2 'bits'.

In Metric Physics Boltzmann's constant can be expressed in various units of measurement, ranging from macroscopic properties such as J/K or Hz/K to microscopic properties such as 'bit' and 'nat'. Below is a table of various representations of k_B in Metric Physics, as was found in Wikipedia:

Values of k_B	**Units**
$1.380\,6488(13)\times10^{-23}$	**J/K**
$8.617\,3324(78)\times10^{-5}$	eV/K
$2.083\,6618(19)\times10^{10}$	Hz/K
$3.166\,8114(29)\times10^{-6}$	EH/K
$1.380\,6488(13)\times10^{-16}$	erg/K
$3.297\,6230(30)\times10^{-24}$	cal/K
$1.832\,0128(17)\times10^{-24}$	cal/°R
$5.657\,3016(51)\times10^{-24}$	ft lb/°R
0.695 034 76(63)	cm−1/K
0.001 987 2041(18)	kcal/mol/K
0.008 314 4621(75)	kJ/mol/K
4.1	pN·nm
−228.599 1678(40)	dBW/K/Hz
1.442 695(04)	bit
1	nat

Table 6.1: Boltzmann's constant k_B, expressed in various units of measurement (source: Wikipedia).

Boltzmann's finding is expressed as follows:

$$S = k_B \,.\ln(w) \qquad (6.1)$$

In the above equation symbol 'S' stands for 'entropy', and 'w' represents the number of states in which an object can be found. It thereby is assumed that each state has equal probability, which is likely in many cases.

All versions of k_B (as shown in table (6.1)) can be entered into equation (6.1). Consequently, the unit of measurement for entropy has as many options. Thereby each of these delivers the entropy value of the object one is investigating, and –obviously- that entropy must represent one and the same underlying physical concept, albeit that it can be expressed in these various units of measurement. This variety of options finds its roots in that these units of measurement are related to each other in an objective and non-relativistic way. Or: these various units of measurement can be converted into each other, whereby the conversion procedure is based on universal natural constants only. This is indeed the case. For example:

- to convert the J/K value (first row in table 6.1) into Hz/K (third row in this table) involves multiplication by Planck's constant 'h'. This conversion rule reflects that Planck's law $\mathbb{E} = h.\upsilon$ defines the relationship between energy (in Joules) and frequency (in Hertz).
- To convert from 'nat' (last line in table) towards Hz/K (third line in table) one needs to divide the 'Planck angular frequency' (=1.85487 x 10^{43} s^{-1}) by $2.\pi$ time the Planck temperature (=1.416833x10^{32}K).

The 'bit' and the 'nat' are mathematical units just like 'π' and 'e'. These are non-relativistic, universally equal to all. The consequence thereof is that each and every other unit of measurement it table (6.1) also must be non-relativistic. E.g. the J/K is a ratio, and this ratio must be non-relativistic whereas the nominator 'J' and denominator 'K' of this ratio are subject to the observer's circumstances. Per table (6.1) Boltzmann's constant thus establishes objective rules between various units of measurement that must apply to any system of units of measurement.

Let's now review Boltzmann's findings from the Crenel Physics perspective, thereby starting at micro-scale: the entropy-atom. And from there we will expand to the macroscopic world.

a) <u>The universal yardstick for entropy: ln(4).</u>

The entropy-atom was found to have a fixed and unambiguous entropy value of 2 'bits'. Therefore it can be found in 4 different states (e.g. represented by 00, 01, 10 and 11), and in equation (6.1) parameter 'w' equals 4. When substituted herein we get:

$$2\,'bits' = \ k_B.\ln(4) \qquad (6.1a)$$

Mathematically 1 'bit' (=logarithm base 2) is equal to ln(2) 'nat'. Note that 'nat' stands for: natural logarithm = logarithm base 'e'. This explains why in table (6.1) Boltzmann's constant is not only listed to equal 1 'nat', but also to equal 1.442695 'bit'. The conversion factor between these two equals ln(2).

Mathematics also says that 2.ln(2) equals ln(2^2) = ln(4), which is a dimensionless number. When substituted in equation (6.1a) this gives:

$$\ln(4) = k_B.\ln(4) \tag{6.1b}$$

This equation gives us the first version of Boltzmann's constant in Crenel Physics: k_B = 1 (dimensionless). Note that the 'nat' is equal to the dimensionless 1. We will nevertheless show the 'nat' in some equations to indicate the relationship with Boltzmann.

When reviewing the last two rows in table (6.1), in Metric Physics the 'bit' also is one of the units of measurement along the entropy scale with numerical value 1.442695. And the 'nat' is the *normalized* unit of measurement along this same scale (the numerical value equals 1). Thus, Boltzmann's constant connects Metric Physics to Crenel Physics: in both models it has the same normalized value (1 'nat'). Or: *there is no difference between Metric Physics and Crenel Physics when it comes to Boltzmann's constant.*

The earlier definition of the entropy-atom (see chapter (2b)) can now be reworded as follows:

> **The 'entropy-atom' is the smallest detectible object (in terms of complexity). It contains an entropy value 'S' of ln(4), which is a dimensionless number.**

To further explore entropy in the Crenel Physics model, assume an object that is composed of two entropy-atoms. Each individual entropy-atom can reside in 4 different states, such that the combination of the two can be found in 4^2 different states. More in general, some object that is composed of 'n' entropy-atoms (whereby 'n' is some natural number) can be found in 4^n states. This is expressed in the equation below:

$$S_n = \ln(4^n) = n.\ln(4) \tag{6.2}$$

The equation shows that the entropy of an object (that is composed of entropy-atoms) grows proportionally with the number of contained entropy-atoms. This makes the property entropy to obey the general conservation law: if one combines an object 'A' with an object 'B', the entropy of the combination equals the summation of both entropies A plus B. (Note: this will be enhanced in chapter 7)

In comparison with Boltzmann's equation (6.1), in equation (6.2) the Boltzmann constant has the value of the dimensionless 1, per lowest

row of table (6.1). Thereby, equation (6.2) not only applies to the microscopic scale in which we are working here. In Crenel Physics it has been postulated that the universe is constructed of entropy-atoms, the simplest possible detectable objects in terms of complexity. Therefore, in Crenel Physics equation (6.2) also applies to very large values of 'n'. That is: to ensembles. In Crenel Physics the difference between *microscopic* and *macroscopic* does not exist. Or: in Crenel Physics there are no separate leagues for microscopic and macroscopic units of measurement.

Equation (6.2) also delivers the yardstick (or: unit of measurement, symbol 'UoM') for entropy:

$$1\ UoM\ (S) = \ln(4)'\ nat' = \ln(4) \tag{6.3}$$

That amount of entropy applies to the entropy-atom, it is non-relativistic, and it is equal between Metric Physics and Crenel Physics. In conclusion:

> **Entropy is quantified, and comes it steps of size ln(4).**

b) Temperature T_{CP}, ensemble-temperature T_{ECP}., and appearing temperature T_{ACP}.

In chapter (2.c) 'temperature' T_{CP} was based on the pace of the information streams between entropy-atoms. Thereby each individual entropy-atom has its own temperature value T_{CP}. We used Planck's equation: $\mathbb{E} = h.v$. In chapter (2.d) this led to equation (2.7):

$$1\ UoM\ (T_{CP}) \equiv \frac{1\ Package}{h_{CP}} \tag{6.4}$$

Because h_{CP} = 1 C.P, per equation (6.4) the temperature T_{CP} is expressed in Crenels^{-1}, which in turn is equal to the Package because P.C=1 (see equation 2.3). Thus:

> **T_{CP} has a numerical value between 0 and 1, which number expresses the amount of Packages that is contained by the entropy-atom at hand.**

One can now review an ensemble of entropy-atoms. The above equation defines one-on-one relationships between the various entropy-atoms within the ensemble in a static manner. The model is correct if one requires the individual entropy-atoms within the ensemble to be fixed in some single state. Envision e.g. a crystal structure wherein each of the entropy-atoms is frozen into one single state.

However, within an ensemble the various entropy-atoms may possibly reside in various states. Consequently, the information stream between two ensembles must contain *additional* information relative to the current Crenel Physics model. The magnitude of that additional information stream must be related to the degrees of freedom (or number of states) that individual entropy-atoms find within their respective ensembles. We can now upscale the current Crenel Physics model by still using Boltzmann's equation (6.1). Therefore, assume that within some type of ensemble each entropy-atom can reside in 'x' different states. In such case the information stream between two of these ensembles must also contain that additional state information. Also, per equation (6.2) this would make the entropy of the ensemble a factor 'x' times higher. Boltzmann's equation therefore is *recursive*: it can be applied to one single entropy-atom, to an ensemble of entropy atoms, but also– along the same reasoning- to an ensemble of ensembles. And also to ensembles of ensembles of ensembles, etc.. Thereby, each time one is up-scaling to the next higher ensemble layer, the summation of underlying entropies can be represented by (or: reduced to) a constant factor. Thus, the entropy of the entire universe can be constructed using layers of ensembles. But also: the entire universe entropy can be drilled down all the way to the lowest possible layer that is represented by the smallest possible detectable object: the entropy-atom. Between the various layers the only parameter is the number of states in which ensembles can reside within their next upper level. Thereby each ensemble is not only characterized by its private entropy, but also by a private parameter which –only at the lowest level- was named T_{CP}, and which represents the Package content of the individual entropy-atom. To differentiate, we will refer to the temperature of an ensemble as 'ensemble temperature', symbol T_{ECP}.

T_{ECP} is the temperature of an ensemble.

c) <u>Temperature and entropy in Metric physics.</u>

Let's now address how the properties 'entropy' and 'temperature' are introduced and linked to each other in Metric Physics. In table (6.1)

there are 9 units of measurement where the Kelvin is shown in the denominator. Behind each of these is a scenario that involves a unit of measurement in the nominator: J, eV, Hz, etc.. We will limit the review here to some that are relevant to the Crenel Physics model in its current state of development.

As the first scenario, in Metric Physics the entropy 'S' is expressed in J/K. This option is listed in the first row of table (6.1). This leads to:

$$Entropy = k_B \times \frac{Energy\ (in\ J)}{Temperature\ (in\ K)} \tag{6.5a}$$

In the above equation, k_B is to be entered in J/K, and its value is: $1.3806488 \times 10^{-23}$ J/K.

In a second scenario the entropy 'S' is expressed in Hz/K, see the third row in table (6.1):

$$Entropy = k_B \times \frac{Frequency\ (in\ Hz)}{Temperature\ (in\ K)} \tag{6.5b}$$

In the above equation, k_B is to be entered in Hz/K, and its value is: 2.0836618×10^{10} Hz/K.

Both equations (6.4a) and (6.4b) obviously lead to the same 'entropy', albeit in different units of measurement. As important here: both equations share their temperature scale (in Kelvin).

Thus, all rows in table (6.1) can be addressed one by one. Per the last but one row of the table entropy is expressed in 'bits':

$$Entropy = k_B \times 'bit' \tag{6.5c}$$

Whereby $k_B = 1.442695 = 1/\ln(2)$ and 'bit' represents the number of bits that are required to represent the object.

And as final scenario the last row of table (6.1) leads to the equation:

$$Entropy = 'nat' \tag{6.5d}$$

Whereby kB=1 and therefore is not shown in the equation, and whereby 'nat' is the number of 'nat' that represents the object.

It was already addressed how Boltzmann's natural units of measurement play a role in converting k_B from one scenario to the other. The important and general conclusion thereby was, that although in Metric Physics historically various apparently unrelated units of measurement were introduced (such as the Joule and the Hertz), these various units of measurement are nevertheless connected to each other via Boltzmann's constant and other universal natural constants. Between the above given scenarios the following rules for mutual conversion are available:

- 1 'nat' = 1/ln(2) 'bit'
- 1 'nat' = 'X' Hz/K,

  whereby 'X' equals the 'Planck angular frequency' (=1.85487 x 10^{43} s^{-1}) divided by 2.π times the 'Planck temperature' (=1.416833x10^{32}K).
- 1 'nat' = 'Y' J/K

  whereby 'Y' equals aforementioned 'X', divided by Planck's constant '*h*'.

All the equations (6.5a), (6.5b), (6.5c) and (6.5.d) are based on a general template:

$$UoM(Entropy) = k_B \times \frac{UoM\ (content)}{UoM\ (Temperature)} \qquad (6.6)$$

'UoM' stands for: Unit of Measurement.

In all Crenel Physics scenarios the 'content' is expressed in Packages, and (per equation 6.3) the unit of measurement for entropy equals ln(4). Therefore, the template equation in Crenel Physics is:

$$\ln(4) = k_B \times \frac{1\ Package}{UoM\ (Temperature)} \qquad (6.7)$$

In chapter (5) four Package based dimensions/appearances were introduced as scenario options: E_{CP}, M_{CP}, F_{CP} and $ITemp_{CP}$. Based on the template equation (6.7) there are as many versions of this equation, as there are dimensions to the Package. And there are as many units of measurement for Boltzmann's constant (and entropy).

This one-on-one relationship applies to both Metric Physics as well as in Crenel Physics. But it must also apply in general. That is: to any other arbitrary system of units of measurement. The bottom line is, that 'Martians' (so to speak) may come up with any system of units of measurement, but as soon as they introduce e.g. 'energy' and 'frequency', the associated units of measurement *must* relate to each other via some natural constant that we named 'Planck's constant'. Planck's constant is a universal natural constant that applies to everyone anywhere, including to 'Martians'.

We can now explore into what template equation (6.7) transposes in case we opt for the 'energy' dimension of the Package. In other words, instead of entering 'Package' into the equation, we want to enter the 'energy' unit of measurement (symbol E_{CP}). In chapter (5) the conversion was given per equation (5.4):

$$1\ Package = \sqrt{\frac{h_{CP}}{G_{CP}}} \qquad (UoM = E_{CP})$$

In order to use the dimension E_{CP} rather than Package as a 'content' parameter in equation (6.7) we therefore must introduce the inverse conversion factor. Equation (6.7) then becomes:

$$\ln(4) = k_B \times \sqrt{\frac{G_{CP}}{h_{CP}}}\ \frac{E_{CP}}{UoM\ (Temperature)} \qquad (6.7a)$$

The above equation (6.7a) is the Crenel Physics counterpart of Metric Physics equation (6.5a) in which k_B was expressed in J/K.

The UoM for 'temperature' is $Crenel^{-1}$, which in turn is equal to Package because P.C=1. In the current 'energy' scenario one therefore needs to use the 'energy' replication of the Package, for which –again- equation (5.4) is to be used. This results in:

$$\ln(4) = k_B \times \sqrt{\frac{G_{CP}}{h_{CP}}}\ \frac{E_{CP}}{\sqrt{\frac{h_{CP}}{G_{CP}}}} \qquad (6.7b)$$

Or:

$$\ln(4) = k_B \times \frac{G_{CP}}{h_{CP}} \qquad (6.7c)$$

Thereby k_B is to be expressed in:
'energy units of measurement'/'temperature units of measurement'. In Metric physics that would be J/K.

Likewise, the counterpart for the frequency dimension F_{CP} of the Package (equation 6.5b) can be derived, using the conversion factor per equation (5.6):

$$1\ Package = \sqrt{\frac{1}{h_{CP}.G_{CP}}} \qquad (UoM = F_{CP})$$

The Crenel Physics counterpart for Metric Physics equation (6.5b) then is:

$$\ln(4) = k_B \times \sqrt{h_{CP} \times G_{CP}}\ \frac{F_{CP}}{UoM\ (Temperature)} \qquad (6.8a)$$

The UoM for 'temperature' again is Crenel^{-1}, which in turn is equal to Package because P.C=1. In the current 'frequency' scenario one therefore must use the 'frequency' replication of the Package, for which –again- equation (5.6) is to be used. This results in:

$$\ln(4) = k_B \times \sqrt{h_{CP} \times G_{CP}}\ \frac{F_{CP}}{\sqrt{\frac{h_{CP}}{G_{CP}}}} \qquad (6.8b)$$

or:

$$\ln(4) = k_B \times G_{CP} \qquad (6.8c)$$

Thereby k_B is to be expressed in:
'Frequency units of measurement'/'temperature units of measurement'. In Metric physics that would be Hz/K.

Equations (6.7c) and (6.8c) describe a relationship between natural constants. Because within some arbitrary system of units of measurement all natural constants are universally equal to all, within such system the above relationships must be equally valid.

d) <u>Verification.</u>

The above two relationships (6.7c) and (6.8c) can be slightly rewritten, and applied to Metric units of measurement. This gives respectively:

$$\boldsymbol{G = \frac{h.\ln(4)}{k_B} \qquad \left(k_B\ in\ {}^{J}/_{K}\right)} \qquad (6.9)$$

And:

$$\boldsymbol{G = \frac{\ln(4)}{k_B} \qquad \left(k_B\ in\ {}^{Hz}/_{K}\right)} \qquad (6.10)$$

In Metric Physics:
h = 6.62606957 x 10^{-34} J.s
k_B = 1.3806488 x 10^{-23} J/K

When these values are substituted in equation (6.9) this gives for G:
G = 6.65316 x 10^{-11} s.K

To substitute the natural constants in equation (6.10) we need the Hz/K version of Boltzmann's constant:
kB = 2.0836618 x 10^{10} Hz/K
This leads to:
G = 6.65316 x 10^{-11} K/Hz

Because the two above used Boltzmann versions in J/K and Hz/K are –as discussed- related to each other (Planck's constant 'h' is the conversion factor between Joules and Hertz) it is inherent that both numerical outcomes of equation (6.9) and equation (6.10) are exactly equal.

In literature one can find the Metric Physics value for G:
G = 6.67384 x 10^{-11} N.m^2.kg^{-2}

Therefore, the results per equations (6.9) and (6.10) equally undershoot the actual value for G by approximately 0.3 percent, or a factor of 0.996902. The difefrence will be addressed in the next chapter.

7. Ensemble temperature.

Equations (6.9) and (6.10) both undershoot the actual value of the gravitational constant G by about 0.3 percent. The plausible cause is embedded into the Crenel Physics model, and it will be further explored here.

Both equations came forth from the postulation that the universe is constructed of 'entropy-atoms', the smallest possible detectable entities. However, when ensembles were introduced, the ensemble temperature T_{ECP} was presumed to be 0 (Packages), based on ignoring the possibility that entropy-atoms could have more than just one state in which they can reside within an ensemble. This sets the information stream –and thereby gravity- between ensembles equal to the summation of contributions of contained entropy-atoms.

Now that we actually calculated a gravitational constant that lies below the value as measured in nature, the conclusion is that the actual information stream between ensembles is slightly (about 0.3 percent) above the information that is generated by the entropy-atoms alone. In other words: the number of states in which an entropy-atom may reside within an ensemble is not –as presumed- equal to 1, but it must have some higher value. And this, in combination with some positive value for the temperature of the ensemble (T_{ECP}) increases the numerical value of G.

Prior to exploring this further, let's quantify how 'big' a single entropy-atom could possibly be, thus putting it into the perspective of the Metric Physics world of elementary particles like e.g. neutrons and electrons.

When we multiply the entropy-atoms entropy ln(4) with the maximum possible temperature T_{CP} (which is 1 Package) that an entropy-atom could possibly have (see chapter 2c) we get an object that contains ln(4) Packages, which corresponds to (see equation (4.5)):

$$\ln(4) \times \sqrt{\frac{h.c}{G}} \quad kg = 7.563 \ \times 10^{-8}\, kg$$

Or per equation 4.6:

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$$\ln(4) \times \sqrt{\frac{c^5}{h.G}} \quad Hz = 1.0259 \times 10^{43}\, Hz$$

Atomic nuclei are in the range of 10^{20} Hz. Therefore, entropy-atoms can potentially have much more 'content' than an atomic nucleus. However, for the maximum 'content' scenario the entropy atoms must have the extremely high Planck temperature of 1.416833 x 10^{32} Kelvin. At room temperature (about 300 Kelvin) an entropy-atom would be around 2 x 10^{13} Hz, such that one would need in the order of ten million entropy-atoms to construct one atomic nucleus. And one would need several thousand entropy-atoms at this temperature to construct one electron. Note however that T_{CP} is not to be confused with T_{ECP}, the temperature we are monitoring when we use a thermometer. T_{CP} cannot be measured that way.

The above considerations demonstrate that elementary particles such as protons and electrons could easily be shaped by just one single entropy-atom: they fall in the 'content' range that can be covered. These particles would fall in the very low range of the entropy-atoms 'content' band. At this point it is not really relevant whether or not elementary particles are 'ensembles' or single entropy-atoms. The fact that these particles cannot be split is a plea for assuming that these are single entropy-atoms. However, it is relevant that at the scale of our universe we found a gravitational constant that goes slightly above what individual entropy-atoms deliver: the difference can be explained by assuming that entropy-atoms have more than one state within an ensemble, in combination with the requirement that such ensembles have some positive temperature.

We might now be tempted to envision an ensemble spatially, thereby creating lots of degrees of freedom for any entropy-atom to physically move and bounce around. It is more rational however to *not* introduce extra dimensions or degrees of freedom beyond what is strictly needed. The logical step forward is the presumption that an entropy atom has no more than two possible states in which it can reside in an ensemble. The reasoning behind this is that this presumption delivers a data stream with a bandwidth of 1 bit. Such 1-bit data stream can represent any broader bandwidth, albeit that one would need a higher bit-rate. Conceptually this is the same approach as followed when the entropy-atom itself was introduced.

The author believes that prior to investing in a further investigation the current model needs conceptual review.