Is gravity based on Boltzmann, Einstein and Planck?

Fundamental Physics

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The intention was to re-think physics from scratch. It led to a revised basis for Boltzmann's constant, and thereby inherently to a revised temperature scale. Both based on minimum detectable objects rather than on micro-states within an object. The consequence:

when Boltzmann's constant k_B is expressed in 'energy units of measurement' divided by 'temperature units of measurement' (in S.I. units of measurement that would be J/K):

$$1\,'nat' = \frac{k_B \times G}{h \times \ln(4)}$$

The values of Planck's constant '*h*' and Boltzmann's constant 'k_B' are known accurately relative to the value of '*G*'. Thus, the equation undershoots the numerical value of the gravitational constant '*G*' –as found in main stream literature- by 0.3%. Finding an explanation for this undershooting is of critical importance for claiming that the above equation is conceptually valid. Prior to starting such search, professionals are invited to review the reasoning that led to the above.

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1. Summary.

This review starts by differentiating between what 'appears' to observers, and what lies underneath. The latter is a more fundamental layer of properties. Such more fundamental layer requires named properties and associated units of measurement. However, no commonly used terminology was found. Therefore, two are introduced: the 'Package' (measured in Packages) and the 'Crenel' (measured in Crenels).

These play a role in the followed normalization procedure. A frequently followed normalization procedure is, to set universal natural constants to unity (the dimensionless 1). In this review only the velocity of light is set to unity. Other universal natural constants have only been numerically normalized, while being expressed in the aforementioned units of measurement Package and Crenel.

This evolves into a model that shows consistency with Planck's normalized units of measurement: these form the conversion factors between Package and the Crenel at the one side, and their various 'appearances' at the other. Einstein's $\mathbb{E} = m.c^2$ and Planck's $\mathbb{E} = h.\upsilon$ form the backbone of the model, in which these two equations are fully embedded (and thus appear to be snowed under, whereas in fact they indeed are fully integrated). The model is named 'Crenel Physics', to avoid confusion with 'Metric Physics'.

This 'Crenel Physics' model then is enhanced by introducing entropy and a temperature scale, based on Boltzmann's equation $S=k_B.\ln(w)$. The important feature of Boltzmann's constant is that it can be expressed in 'nat' or in 'bit', both being mathematical constants that come forth from mathematical procedures (and therefore their values are universal, just like the values for 'e' and 'π'). Boltzmann's constant thus has a universal base that can be shared between individual users and their individual systems of units of measurement.

With the 'Crenel Physics' model being of lower dimension (less units of measurement) while it still fully embeds the aforementioned Einstein, Planck and Boltzmann relationships, the number of natural physical constants –as known in common physics- appears to large. The following relationship was identified:

$$1\ 'nat' = \frac{k_B \times G}{h \times \ln(4)}$$

There are as many versions of the above equation as there are appearances of Boltzmann's constant. The above version assumes Boltzmann's constant to be expressed in 'energy unit of measurement/temperature unit of measurement'. In Metric Physics that would be in J/K. As example an additional version -where Boltzmann's constant is to be entered in Hz/K- is derived.

When entering the numerical values per Metric Physics, the above equation contains an error of 0.3 percent. Such is unacceptable for claiming fundamental coherence in the above equation and in the underlying model. However, the model leaves various options for enhancement.

2. Appearances versus fundamental physical properties.

Humans see colored light. But colors do not exist as such: light particles (photons) do not have a color. It is the *appearance* of colors that exists. One needs color sensors (in the human eye) to become aware of this appearance. Underneath colors is a more fundamental mechanism: photon energy levels relative to the observer. Pending this level, certain color sensors in the eye can be stimulated when hit by photons. Thereby a color appearance is perceived.

Humans standardized perceived colors, agreed on what is 'red' and what is 'blue'. Because the healthy human eye has three different color receptors (red, blue and green), each giving a signal for a specific photon energy band, one needs three signal strengths (or: parameters) to specify all possible color perceptions. The human color system therefore is 3-dimensional. In case humans would have been blessed with 10 different color receptors, the color system would have been 10-dimensional. But there still would be nothing but the 1-dimensional photon energy band underneath.

Color appearances fit into an objective system: one can produce and reproduce any color, based on instructions by telephone. The possibility to instruct by phone is one way of formulating that the involved unit of measurement indeed is objective and 'absolute'.

The example illustrates that the existence of an absolute system of units of measurement is no guarantee that one is measuring a property that truly exists from an objective viewpoint: one is dealing with an appearance of the existing. In this example the 'existing' is a one dimensional photon energy band, while the 'appearance' is a 3-dimensional color system that is reveiled to humans with healthy eyes. Without sensors, the 'appearance' is not possible.

More in general:

> **Any physical property that appears (or: is observed, measured or monitored) is based on sensor signals.**

A sensor gives an output that can be quantified (or: numerically expressed). Besides the example of the aforementioned three color sensors, humans have or developed sensors for time, length, mass, energy, frequency, temperature, force etcetera. Thereby, each sensor type is associated with its own specific unit of measurement.

Thus, in the Metric S.I. system one respectively defined the second, the meter, the kilogram, the Joule, the Hertz, the Kelvin, the Newton, etcetera.

> **It is the availability of a sensor that justifies the associated unit of measurement.**

Physics initially focused on relationships between sensor signals. Thereby one assumed that –for the single reason that a sensor exists- the associated unit of measurement exists as a fundamental physical property. In fact however, only the appearance of such fundamental physical property exists.

This raises the question: what are these fundamental physical properties that lie underneath the various known sensor signals (and their associated units of measurement)?

3. Packages and Crenels

Based on the previous, one may wrongfully suggest that 'energy' is one such fundamental physical property. All colors –in a three dimensional color scheme- can be explained by a one dimensional photon energy band. 'Energy' therefore indeed is more fundamental than 'color'.

A first argument against such suggestion is that energy can be associated with 'frequency' as Planck's law says: '$\mathbb{E} = h.\upsilon$'.

Another argument against it is found in Einstein's equation '$\mathbb{E} = m.c^2$'. It says that energy (in Joules) can be converted into mass (in kilograms), and vice versa.

Thus 'energy', 'frequency' and 'mass' have been related here. Also, all must be categorized as output signals of sensors, and thereby as appearances. They are related to each other because they can be converted into each other, either by using Planck's equation '$\mathbb{E} = h.\upsilon$', or by using Einstein's equation '$\mathbb{E} = m.c^2$'.

Note that the conversion factors between these appearances are based on universal natural constants only (here Planck's constant 'h' and the velocity of light 'c' respectively). Universal natural constants have equal value to all observers, regardless the observer's (or a sensor's) circumstances. Consequently, anyone anywhere will find the same conversion result when converting e.g. a certain sensed mass quantity into a frequency. Or: although the sensed mass and the observed frequency themselves are sensor signals that might be affected by sensor circumstances, the conversion procedure is absolute, provided that the observer's sensors share the same circumstances. Or: to any observer, a certain observed mass is unambiguously associated with a certain frequency, and vice versa. Or: the conversion procedure itself is non-relativistic, whereas the underlying appearances are relativistic (that is: pending sensor circumstances).

Based on the existence of unambiguous relationships between the above mentioned appearances, it is concluded here that there must be a more fundamental physical property underneath the appearances 'energy', 'frequency' and 'mass'. This property should have a name and a unit of measurement. The author searched literature for a commonly used terminology, but could not find it. For

this reason the 'Package' is introduced:

> **The 'Package' is a fundamental physical property that may appear amongst others as 'mass', as 'energy' or as 'frequency'. It will be expressed in 'Packages' (symbol 'P').**

The above definition leaves open the possibility that there might be more appearances of the Package than the aforementioned three.

In order to introduce yet another appearance of the Package it takes:

1. a sensor and an associated –unique- unit of measurement. Without association with a unique unit of measurement the sensor serves no purpose (or: the question 'what is it measuring?' cannot be answered).
2. conversion factors between the various Package-based units of measurement, whereby these conversion factors are to be based on universal natural constants only.
   If not, the conversion procedure does not guarantee a universally equal and non-relativistic conversion procedure. The latter would lead to ambiguity between the various units of measurement, which –in turn- would suggest the existence of a more fundamental physical property underneath.

One related question is whether -in observing an object- all Package appearances could possibly be simultaneously measured accurately. This is not the case. The root cause for that is that all sensors –in some form- interact with the observed object and thereby change the object's properties. In daily life this is not an issue. E.g. one can track the path of a flying airplane because it reflects light. In practice, the light reflection does not impact the airplane's dynamics in a measurable way (in theory it does). Things change, if one tries to track the path of a very small particle. Here, one might have to take the impact of the sensor into account. In such cases one can say something accurate about this path *before* e.g. a photon interacted with the observed object.

In concept, fully accurate simultaneous measurements of appearances are not possible. E.g. for an individual photon one cannot positively verify that its apparent mass is exactly consistent with its apparent frequency. Nevertheless, in main stream physics it is assumed (perhaps is 'postulated' a better word) that *reckoned* mass and *reckoned* frequency –prior to the interaction- are unambiguously related to each other per the given Planck and Einstein equations. Thereby the term 'reckoned' means that one is dealing with a value that would be found, should a hypothetical non-disturbing measurement take place.

Taking into account the aforementioned potential issue related to simultaneous measurements, the following statement is consistent with main stream physics:

> **Any of the known and unknown appearances of the 'Package' is valid at any time. It only depends on the type of sensor one is using, which appearance will be revealed.**

A likewise approach can be followed with another league of appearances: 'time' and 'distance':

- A clock is a sensor for time, and the associated unit of measurement is the 'second'.
  Therefore, 'time' is an appearance.
- A yardstick is a sensor for distance, and the associated unit of measurement is the 'meter'.
  Therefore, 'distance' is an appearance.
- One second can be converted into 'c' meters, whereby 'c' is the velocity of light in vacuum, expressed in m/s.
  The conversion factor is a universal constant: the velocity of light 'c'.

The above meets the criteria for defining another –second- fundamental physical property that lies underneath these two appearances. Again, the author could not find a commonly used terminology in literature. Therefore, it has been named here: the 'Crenel'. This name is inspired by crenellation as found on the top of castle walls: such shape represents a binary function, which is in turn the most elementary option for an enrolling process.

> **The 'Crenel' is a fundamental physical property that may appear amongst others as 'distance' or as 'time'. It will be expressed in 'Crenel' (symbol 'C').**

The terminology so far is summarized in the following figure:

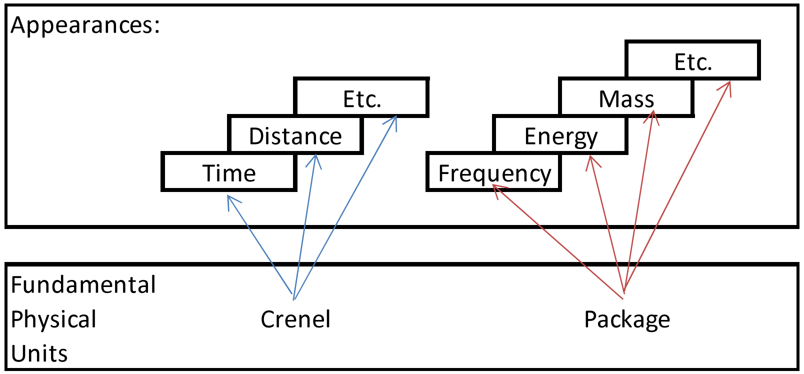

Figure 3.1: Crenel Physics model: an 'Appearances' layer on top of a 'Fundamental Physical Units' layer.

Thereby the following additional comments are made:

- The Package describes the 'what' of an observation, whereas the Crenel describes the 'where and/or when'. Both fundamental physical units may be seen as the 'Yin and Yang' of physics.
- There is no reason given, why there couldn't be any additional fundamental physical units beside Package and Crenel.
- There is no reason given, why there couldn't be an even more fundamental layer beneath the shown layer of 'fundamental physical units'.

To avoid confusion in terminology in the next chapters, the terms 'Metric Physics' and 'Crenel Physics' are introduced:

- **The term 'Metric Physics' refers to terminology from main stream physics, even where the units of measurement might not be metric.**
- **The term 'Crenel Physics' refers to describing physics according to the current model per Figure (3.1).**

4. Considering physical equations and parameters.

Consider velocity.

In Metric Physics its magnitude is expressed in m/s. This unit of measurement is a ratio: meters divided by seconds. No person understands how one could possibly divide a 'meter' by a 'second'. And yet, in daily life this ratio is used intuitively. This intuition does not support the fact that there is an objective maximum to velocity: the velocity of light in vacuum (symbol 'c'), which is equal to all. Why should there be a maximum number of 'meters' that could possibly be divided by one 'second'? The existence of such maximum is not embedded in the definition of 'velocity': it is based on a broader theory: the theory of relativity. This theory is verified in practice and will not be disputed here.

In Crenel Physics however, velocity will be –through conversion of the aforementioned m/s- expressed in Crenel (in its 'distance' appearance) divided by Crenel (in its 'time' appearance).

> **'Velocity' is the appearance, subjective to the observer, expressing the *rate of exchange* of one 'distance' appearance of an object's world into its 'time' appearance.**

This definition makes the unit of measurement for velocity dimensionless: velocity is expressed as a number in the range from 0 to 1. The value 'de facto' expresses velocity as a fraction of light speed. The above definition embodies that velocity has a maximum value of 1: this value corresponds to full conversion. One cannot expect more than full conversion. The definition effectuates a 'normalization' (setting to unity) of the velocity of light.

> *Since the 1880-ties, likewise normalizations of natural constants have been practiced, e.g. leading to 'Stoney units' and 'Planck units' of measurement. As will be discussed later, in Crenel Physics only the velocity of light is set to unity.*

The above definition of velocity embeds a conservation law. In observing an object's velocity, only an apparent (to the observer) exchange from Crenels into Crenels takes place. From a purely objective viewpoint (if one could define such viewpoint) in such exchange process no Crenels are gained or lost. Although different

observers may find different velocities in monitoring an object, this conservation of Crenels holds for all.

The single reason for differentiating between the two types of Crenel appearances (time and distance) is that healthy humans have two separate Crenel sensors:

- one for 'distances' in a 3-dimensional spatial space, whereby the 'meter' is the associated unit of measurement.
- one for 'time', whereby the 'second' is the associated unit of measurement.

Without these two separate sensors, 'velocity' could not possibly be observed. As stated before: the existence of these two separate sensors is no valid justification for assuming that 'time' and 'space' represent separate and independent *fundamental* properties. They do not because they can be converted into each other, with '*c*' as the conversion factor, whereby '*c*' is a natural constant. One can still rightfully argue that this does not make 'time' equal to 'distance'. Indeed: 'time' is a different dimension relative to 'distance'. Take thereby into consideration that in a 3-dimensional space with axis X, Y and Z the 'X' dimension is not the same as the 'Y' dimension either: these are different dimensions. Therefore the question is not whether 'time' and X and Y and Z are mutually equal (they are not). The question is: do these represent a different physical concept and do they therefore have different properties (and should be dealt with in a different manner?). The answer to that is: they do not. 1 second *is* 'c' meters. The 'time' dimension is just another coordinate, just like X, Y and Z, and it has equal underlying properties. That makes velocity in a 3-dimensional spatial space a 4-dimensional appearance with 4 conceptually likewise dimensions. In Metric Physics this approach is also –sometimes- followed: it is generally referred to as a Minkowski space, named after the mathematician who proposed it.

For convenience, several parameters that are commonly used are listed in the table below. Note that in Crenel Physics symbol 'C' stands for Crenels, and symbol 'P' stands for Packages.

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: units of measurement for various appearances.

One objective of Crenel Physics is to review universal natural constants. The –to this document- most important are:

1. Velocity of light 'c'.

   Through the definition of 'velocity' in Crenel Physics the velocity of light was inherently normalized to the

   dimensionless value 1, that is: to 'unity'.

2. Planck's constant 'h'.

   This constant will now be quantified by defining that:

   an object with an angular frequency 'ω' of 1 radial per Crenel contains 1 Package.

   Planck's equation $\mathbb{E} = h.\upsilon$ in Metric Physics thus can be written in Crenel Physics units of measurement as follows:

$$\mathbb{E}(in\ Packages) = h_{cp}.\omega\ (in\ Crenels^{-1}) \qquad (4.1)$$

   If 'ω' equals 1 (radial/Crenel), the contained energy '$\mathbb{E}$' equals 1 (Package), whereby in Crenel Physics Planck's constant h_{cp} equals 1 P.C (the subscript 'cp' indicates the 'Crenel Physics' version of Planck's constant).

   Equation (4.1) can also be expressed in full revolutions per Crenel, whereby symbol 'υ' represents the object's frequency (revolutions/Crenel):

$$\mathbb{E}(in\ Packages) = \frac{h_{cp}}{2.\pi}.\nu(in\ Crenels^{-1}) \qquad (4.2)$$

   In metric Physics, besides Planck's constant 'h' one also uses the 'reduced Planck constant', symbol '$\hbar$'. This is Planck's constant divided by a factor $2.\pi$. In line with this convention the 'reduced Planck constant' is also introduced in Crenel Physics. Equation (4.2) can then be written as:

$$\mathbb{E}(in\ Packages) = \hbar_{cp}.\nu(in\ Crenels^{-1}) \qquad (4.3)$$

   Whereby:

$$\hbar_{cp}(in\ C.P) = \frac{1}{2.\pi}.h\ (in\ C.P) \qquad (4.4)$$

3. Gravitational constant 'G'.

   This constant can be normalized by defining that:

   two objects that each contain 1 Package, at a mutual distance of 1 Crenel, experience a mutual gravitational attracting force of 1 P/C.

   The equation for the gravitational force is as follws:

$$F_G = G.\frac{m_1.m_2}{d^2} \qquad (4.5)$$

   The gravitational constant in Crenel Physics then is: G_{cp}= 1 C/P. Note that the subscript 'cp' thereby again indicates the gravitational constant in Crenel Physics units of measurement.

The following table summarizes the aforementioned:

Natural constant	Symbol	Value in Metric Physics	Value in Crenel Physics
Velocity of light in vacuum	*'c'*	299,792,458 m/s	1 (dimensionless)
Planck's constant	*'h'*	6.62606957 x 10^{-34} J.s	1 P.C

Reduced Planck constant	'$\hbar$'	1.0545717×10^{-34} J.s	$\frac{1}{2.\pi} \times P.C$
Gravitational constant	G	6.67384000x 10^{-11} Nm^2kg^{-2}	1 $C.P^{-1}$

Table 4.2: universal natural constants.

5. Conversion factors.

From table (4.2) the factors for converting Crenel Physics units of measurement (the Package and the Crenel) into Metric Physics units of measurement can be derived. Starting point is that:

$c_{cp} = c$ (5.1)
$h_{cp} = h$ *(see comment below…)* (5.2)
$G_{cp} = G$ (5.3)

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 Metric Physics versions are to be expressed in Metric units of measurement.

These three equations make it possible to calculate conversion factors for the Crenel and the Package towards Metric Physics units of measurement.

Prior to that there is a comment to make on equation (5.2):

> In Metric Physics, Planck's equation $\mathbb{E} = h.\upsilon$ converts the *frequency* of an object (in Hertz) into its contained energy (in Joule), whereas in Crenel Physics Planck's equation $\mathbb{E} = h_{cp}.\omega$ converts the *angular frequency* 'ω' of an object (expressed in radials/Crenel) into its contained energy (expressed in the energy unit of measurement, the Package). An object that has a frequency of 1 cycle per Crenel has an angular frequency of $2.\pi$ radials/Crenel, and therefore it contains $2.\pi$ Packages.

The *mathematical* basis for the measurement of rotational speed is to be set equal between Metric Physics and Crenel Physics. That is: in equation (5.2) one needs to:

- Either select full revolutions per time unit as a measure,
- or select angular frequency in radials per time unit as a measure.

In Crenel Physics, the angular frequency in radials/time unit has

been selected. As will be shown below, this results in conversion factors that are equal to the well known 'Planck units of measurement'.

In Metric Physics, Planck's equation –also using the radials/time unit- is: $\mathbb{E} = \hbar.\omega$. Therefore, Planck's constant in Crenel Physics ('h_{cp}') is to be matched with the *reduced* Planck unit '$\hbar$' in Metric Physics. Taking this into account, equation (5.2) thus becomes:

$$h_{cp} = \hbar \quad \text{(based on radials/time unit)} \qquad (5.2)$$

The three above equations -including their units of measurement- thus are as follows:

1 (dimensionless) = c ($m.s^{-1}$) (5.1a)
1 P.C = $\hbar$ (N.m.s) (5.2a)
1 $C.P^{-1}$ = G (Nm^2kg^{-2}) (5.3a)

In equation (5.2a) 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 = $\hbar$.c ($N.m^2$) (5.2c)

Based on Einstein's $E=m.c^2$, 1 kg corresponds to c^2 Joules or c^2 (N.m). In equation (5.3a) the kg^{-2} in the unit of measurement can thus 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}) (5.3c)

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

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

Or:

$$1\,Package = \sqrt{\frac{\hbar.c^5}{G}}\,Joule \qquad (5.4)$$

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

$$1\ Package = \sqrt{\frac{\hbar.c}{G}}\ kg \qquad (5.5)$$

Because $= \ \hbar.\omega$, 1 Joule corresponds to $1/\hbar$ rad/s. Equation (5.4) can thus be converted to angular frequency:

$$1\ Package = \sqrt{\frac{\hbar.c^5}{G}} \times \frac{1}{\hbar}\ rad/s = \sqrt{\frac{c^5}{\hbar.G}}\ rad/s \qquad (5.6)$$

Multiplying equation (5.2c) with equation (5.3c) gives:

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

Or:

$$1\ Crenel = \sqrt{\frac{\hbar.G}{c^3}}\ meter \qquad (5.7)$$

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

$$1\ Crenel = \sqrt{\frac{\hbar.G}{c^5}}\ seconds \qquad (5.8)$$

The found conversion factors are equal to the so called 'Planck units' (also called 'natural units') as known in Metric Physics, respectively 'Planck energy', 'Planck mass', 'Planck angular frequency', 'Planck distance' and 'Planck time'. This equality finds it's roots in the definition of the Package, being based on angular frequency (in radials/Crenel) rather than orbit frequency (in orbits/Crenel). Had the latter been selected –which conceptually is a valid option- all reduced Planck constants in he above conversion factors are to be replaced by Planck's constant. There is an obvious 'selling point' advantage to normalize the Package such that full consistency with the well-known Planck units is achieved.

Thus, the normalization procedure in Crenel Physics is *not* a 'non-dimensionalization' of all natural constants (= the setting all physical

constants to 'unity'), as sometimes is done in Metric Physics. In Crenel Physics only the velocity of light was found dimensionless, whereas 'h' is expressed in 'P.C' and 'G' is expressed in 'C/P'. One still uses the Package and the Crenel as separate units of measurement for expressing universal natural constants.

6. The relationship between Package and Crenel.

In Crenel Physics, the Package and the Crenel were introduced independently, based on two groups of appearances. This suggests that the Package and the Crenel are two independent units of measurement. However, at closer look this is not the case. The relationship between both units of measurement is inherently settled by defining that: 'an object with an angular frequency of 1 radial per Crenel contains 1 Package'. More in general, for any numerical value of 'XYZ':

$$XYZ\ Packages\ \equiv XYZ\ \frac{Radials}{Crenel} \qquad (6.1)$$

Therefore, according to equation (6.1) the unit of measurement Crenel is the inverse to the unit of measurement Package. This is expressed by the following equation:

$$P.C = 1 \qquad (6.2)$$

Equation (6.2) expresses, that the units of measurement Package and Crenel cannot be seen independent from each other: in terms of quantifying a property there is exchangeability between Packages (the 'what') and the Crenel (the 'where/when'). The statements 'this object contains 5 Packages' and the statement 'this object contains 5 Crenels^{-1}' are equal.

Equation (6.2) embodies a one-on-one conservation law for a material object that resides in a space/time world: where Packages disappear, Crenels appear, and vice versa, such that their product remains constant. The value '1' at the right side of equation (6.2) also is the value of the velocity of light. Thus, equation (6.2) can be worded as:

> **The unit of measurement Package, multiplied with the unit of measurement Crenel equals the Velocity of Light (in vacuum).**

The remarkable in the above is the complete absence of any mathematical number: the multiplication of two physical concepts (the 'what' and the 'when/where') results in a third physical concept: the velocity of light.

Both Packages and Crenels have various appearances that were already addressed. For each possible combination of Package/Crenel appearances the aforementioned product P.C can be reviewed. In Crenel Physics, for any combination this value would –due to the followed normalization procedure- be 1, as shown in the following table:

	Energy (in Packages)	Mass (in Packages)	Angular Frequency (in Packages)
Time (in Crenel)	1	1	1
Distance (in Crenel)	1	1	1

Table 6.1: the product P.C in Crenel Physics units of measurement, for various appearance combinations.

To convert this table into Metric Physics the respective conversion factors per chapter 5 would need to be used, as shown below:

	Energy (in Joules)	Mass (in kg)	Angular Frequency (in rad/s)
Time (in seconds)	$\sqrt{\frac{\hbar.G}{c^5}}.\sqrt{\frac{\hbar.c^5}{G}}$	$\sqrt{\frac{\hbar.G}{c^5}}.\sqrt{\frac{\hbar.c}{G}}$	$\sqrt{\frac{\hbar.G}{c^5}}.\sqrt{\frac{c^5}{\hbar.G}}$
Distance (in meters)	$\sqrt{\frac{\hbar.G}{c^3}}.\sqrt{\frac{\hbar.c^5}{G}}$	$\sqrt{\frac{\hbar.G}{c^3}}.\sqrt{\frac{\hbar.c}{G}}$	$\sqrt{\frac{\hbar.G}{c^3}}.\sqrt{\frac{c^5}{\hbar.G}}$

Table 6.2: the product P.C in Metric Physics units of measurement, for various appearance combinations.

The above table contains the various conversion factors as found in chapter 5. It can be simplified as follows:

	Energy (in Joules)	Mass (in kg)	Angular Frequency (in rad/s)
Time (in seconds)	$\hbar$	$\frac{\hbar}{c^2}$	1
Distance (in meters)	$\hbar . c$	$\frac{\hbar}{c}$	c

Table 6.3: the product P.C in Metric Physics for various appearance combinations.

As expected, there is much symmetry in this table:

- Regardless the selected Package appearance, the shift between 'time' and 'distance' appearance (a shift between rows) involves multiplication/division by a factor 'c'.
- Regardless the Crenel appearance, the shift between various Package appearances (a shift between columns) involves the same mathematical operation.
  E.g. shifting from the Energy appearance to the Angular Frequency appearance requires a dividing by '$\hbar$', regardless the selected Crenel appearance (selected row). This example represents Planck's equation ($\mathbb{E} = \hbar . \omega$). But in Crenel Physics this recipe is demonstrated to be valid for both 'time' appearances as well as for 'distance' appearances. Likewise, Einstein's equation $E=mc^2$ is embedded in the shift between the Energy and Mass columns.

It is perhaps more relevant here that the gravitational constant 'G' plays no role whatsoever in safeguarding the fact that P.C=1 , whereas it does play a role in the individual conversion of each appearance value. In the conversion factors (per chapter 5), all Crenel appearances are found proportional to $\sqrt{G}$, whereas all

Package appearances are proportional to $\sqrt{\frac{1}{G}}$.

The above table leaves room for expansion, allowing other appearances to be introduced in extra rows (for extra Crenel appearances) or columns (for extra Package appearances). The above findings thereby suggest extrapolation of symmetry rules as discussed, and furthermore -in particular- with regards to the independency on 'G' . This is the first indication that the natural constant 'G' (as known in Metric Physics) belongs in a separate league. As will be shown later, 'G' will turn out to be based on Planck's constant ('h') and Boltzmann's constant ('k_B'), and therefore is not a separate universal physical constant.

7. Temperature and Boltzmann's constant.

Chapter 3 introduced the 'fundamental physical units' Package and Crenel. Chapter 5 gave conversion factors for:

- the Package towards the appearances 'mass', 'energy' and 'frequency' and
- the Crenel towards the appearances 'distance' and 'time'.

See equations (5.4) through (5.8) respectively.

This chapter addresses the physical appearance: 'temperature'. It relates to Boltzmann's constant (symbol 'k_B'), another natural constant.

Other than the appearances so far, temperature is a *macroscopic* appearance, to be associated with a bulk quantity of matter: the statistics of large numbers play a role. Imagine e.g. a gas container. The temperature reading of a thermometer within this container is related to the impulse of gas molecules that collide with the temperature sensor. Per individual molecule this impulse differs according to a probability curve. Thus, by coincidence and relative to the bulk, the group of nearby molecules typically will temporarily have higher or lower than average impulse. This causes the temperature reading to fluctuate. As the thermometer sensor is thought smaller, the smaller this nearby group will be, and the less the averaging effect. Or: the smaller the sensor, the noisier it's reading. In case of extreme miniaturization, temperature measurement would only make sense if the reading is averaged over a prolonged period of time. In all cases such averaged reading does –within statistical uncertainty- match the temperature of the bulk. That's why the appearance temperature is macroscopic. The term 'macroscopic' can be replaced by 'statistical'. Through statistical rules the relationships between thermometer size, gas density, measurement averaging time and noise level can be formulated.

In Crenel Physics, the purpose of 'temperature' is defined broadly as follows:

> **Temperature is a statistical appearance to quantify a macroscopic rate of exchange between two bodies.**

A 'body' is defined as:

> **A 'body' is an ensemble (= large number) of detectable particles. The number is large enough to make the contribution of one individual particle irrelevant from a statistical point of view.**

Initially, the temperature based exchange focussed on 'heat flow' between two bodies. The studying of this heat flow helped to optimize steam engines. Later, radiation as well as statistical physics came into the picture. As physics progressed, the role of 'temperature' became broader. For this reason it is left open in Crenel Physics, what other types of macroscopic exchanges might be 'temperature' based.

The size of the two interacting bodies –large or small- is not relevant to the direction and magnitude of the exchange. E.g. as heat starts flowing from a hot body towards a cold body, the temperature between the two bodies will equalize in due time. That sets the direction of the heat flow. Its magnitude (measured at any instant moment in time) entirely depends on the temperature difference and on the easiness of heat exchange. E.g. if a droplet of hot water contacts a droplet of cold water, the initial heat flow between both droplets might be large in comparison to what is found if one immerses an insulated container filled with hot water into a cold aquarium.

Crenel Physics requires a unit of measurement for the 'temperature' of a body. Metric Physics uses several scales. Degrees Celsius (symbol ^{0}C) and Kelvin (symbol K) are commonly used. The Kelvin scale makes most sense from a scientific viewpoint because it's zero value coincides with the impossibility to deliver something. At 0 K anything that could possibly be withdrawn from a body *has* been withdrawn. That's why the scale is 'absolute'. Exchange can only take place towards the 0 K body. This constraint inherently sets the sign convention for the flow direction of the exchange. Regardless of what is exchanged: the convention is that the flow towards a 0 K body is named positive. More in general: the exchange from a higher temperature body to a lower temperature body has the positive sign.

In Metric Physics, the unit of measurement on this absolute Kelvin temperature scale is directly linked to Boltzmann's constant (symbol 'k_B'):

$$1\,Kelvin = \frac{1\,unit\ of\ Energy}{k_B} \qquad (7.1)$$

Here the unit of energy is the Joule. This implies that in the above equation Boltzmann's constant is to be expressed in Joules per Kelvin. Its value can be found in literature:

$$k_B = 1.3806488 \times 10^{-23} \frac{Joule}{Kelvin} \tag{7.2}$$

As was discussed, from the perspective of Crenel Physics the 'Joule' is just one of various appearances of the Package. Frequency and mass were other appearances.

In Metric Physics the Boltzmann constant is expressed in a variety of appearances. The following table can be found in Wikipedia, and gives an overview of commonly used units of measurement (and their associated values):

Values of k_B	Units
1.380 6488(13)×10^{-23}	J/K
8.617 3324(78)×10^{-5}	eV/K
2.083 6618(19)×10^{10}	Hz/K
3.166 8114(29)×10^{-6}	EH/K
1.380 6488(13)×10^{-16}	erg/K
3.297 6230(30)×10^{-24}	cal/K
1.832 0128(17)×10^{-24}	cal/°R
5.657 3016(51)×10^{-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 7.1: Boltzmann's constant, expressed in various units of measurement (source: Wikipedia).

To define a temperature scale in Crenel Physics, the same approach is followed. The following symbols are introduced:

- for the 'Temperature' unit of measurement 'T_{CP}', and

- for Boltzmann's constant '$k_{B(CP)}$'.

The subscript 'CP' thereby stands for: the 'Crenel Physics' version thereof. In line with Metric Physics, this leads to the following definition:

$$1^0\, T_{CP} = \frac{Energy\ unit\ of\ measurement}{K_{B(CP)}} \tag{7.3}$$

In Crenel Physics, the Energy unit of measurement is the Package. Therefore, equation (7.3) can be written as:

$$1^0\, T_{CP} = \frac{1\ Package}{K_{B(CP)}} \tag{7.4}$$

The 'Package' already has been quantified, but the value for Boltzmann's constant $k_{B(CP)}$, has not yet been discussed. Once decided for some value, this inherently sets the temperature scale per the above equation.

Table (7.1) gives guidance to make such decision: it says that in Metric Physics:

$$k_B = 1.3806488 \times 10^{-23} \frac{Joule}{Kelvin} \equiv 1.442695\ bit \equiv 1\ nat$$

See the first row and the last two rows in Table (7.1). In particular the last two units of measurement are of interest here: the 'bit' and the 'nat'. These are mathematical, as e.g. the constants 'π' and 'e' are mathematical. Mathematical constants are universal and non-relativistic. Or: regardless the system of units of measurement and regardless circumstances, 'π' remains 'π', 'e' remains 'e', a 'nat' remains a 'nat', and a 'bit' remains a 'bit'. The reason for the universal applicability of mathematical constants is that these come forth from mathematical procedures. Mathematical procedures are equal to all observers and therefore objective (or: non-relativistic). E.g. the value of 'π' comes forth from fitting a circle's diameter into its circumference: it fits 'π' times, regardless the observer's circumstances relative to the circle (different observers might see a different size of that circle, pending their relativistic circumstances, but they all would find the same value for 'π').

The 'bit' is a unit of measurement for 'information entropy'. It's relation to the 'nat' is mathematical: 1 'bit' = 1/ln(2) 'nat'. The reason for the conversion factor 1/ln(2) will be addressed later.

Given the above, it is only practical to select the option that in Crenel Physics Boltzmann's constant also (as in Metric Physics) equals 1 'nat'. That choice makes the mathematical concept 'information entropy' the binding factor between the Metric Physics and Crenel Physics version of Boltzmann's constant:

$k_B = k_{B(CP)} = 1$ 'nat'.

Thus, equation (7.4) can be simplified to:

$$1^0\ T_{CP} = \frac{1\ Package}{k_B} \qquad (7.5)$$

Technically, to convert $1^0\ T_{CP}$ into 1 Kelvin, one must convert both nominator and denominator in the above equation into Metric units of measurement. One can optionally convert the 'Package' in equation (7.5) into Joules, or Hz, or kg (or whatever other appearance might be associated with the Package). Based on the selected option, one must express Boltzmann's constant into the corresponding Metric Physics version. That is: in J/K, Hz/K or kg/K respectively. The first two values for k_B are listed in table 7.1 (1st and 3rd row). The kg/K seems less common and is not listed there. But the numerical value of Boltzmann's constant when expressed in kg/K would differ a factor c^2 from the J/K value, based on Einstein's equation: $\mathbb{E} = m.c^2$.

In case one opts to convert the Package in the nominator of equation (7.5) into Joule, the conversion factor is given in chapter 5, see Equation (5.4):

$$1\ Package = \sqrt{\frac{\hbar.c^5}{G}}\ Joule \qquad (7.6)$$

In that case, equation (7.5) can then be written as:

$$1^0\ T_{(CP)} = \sqrt{\frac{\hbar.c^5}{G.(k_B)^2}}\ \ {}^0K \qquad (7.7)$$

whereby 'k_B' is to be expressed in J/K.

In case one opts to convert the Package into Hertz, the conversion factor is given by Equation (5.6):

$$1\ Package = \sqrt{\frac{c^5}{\hbar.G}}\ (\frac{rad}{s}) = \frac{1}{2.\pi}\ .\sqrt{\frac{c^5}{\hbar.G}}\ (Hz) \qquad (7.8)$$

whereby 'k_B' is to be expressed in Hz/K.

Both scenario's lead to the same value for $1^0\ T_{(CP)}$.

Verification:
The numerical value of the Package -when expressed in Hz per equation (7.8)- is an exact factor $2.\pi.\hbar = h$ less relative to the numerical value of the Package when expressed in Joule per equation (7.6). Both equations (7.6) and (7.8) must lead to equal results for the temperature scale. This requires that 'k_B' -when expressed in Hz/K- must be a factor 'h' less (relative to expressing k_B in J/K). Using table (7.1), see the 1st and 3rd row, it can be verified that this indeed is the case:

$$\frac{k_{B\ (in\ J/K)}}{h\ (in\ J)} = \frac{1.380\,6488(13) \times 10^{-23}\ (J/K)}{6.626\,069\,57(29) \times 10^{-34}\mathrm{J}}$$

$$= 2.083\,6618(19) \times 10^{10} \left(\frac{Hz}{K}\right)$$

$$= k_B\ \left(in\,\frac{Hz}{K}\right) \qquad (7.9)$$

In conclusion: the selected option for the unit of measurement of the Boltzmann's constant (J/K, Hz/K or kg/K) does –as expected and required- not impact the unit of measurement for temperature in Crenel Physics. This temperature unit of measurement (per equation 7.7) is equal to the so called 'Planck Temperature'. In retrospect, the root cause of finding the 'Planck temperature' is twofold:

1. The selected option in Crenel Physics to set Boltzmann's constant to equal 1 'nat'.
   Through this selection both the numerical value of

Boltzmann's constant (=1) as well as its unit of measurement (='nat') is shared between Metric Physics and Crenel Physics. Or: Boltzmann's constant is equal in both systems of units of measurement.

2. The found conversion factors between the Package and the Joule/Hz/kg respectively (see chapter 5).
These factors were found to be equal to 'Planck Energy', 'Planck Frequency' and 'Planck Mass' respectively.

Where table (7.1) shows a wide variety of appearances of Boltzmann's constant as used in Metric Physics, at this point and for now the appearance list that is relevant to Crenel Physics is shorter. The following table is an abstract of table (7.1), showing only the appearances that have been discussed so far in Crenel Physics:

Values of k_B	Units
$1.380\,6488(13)\times10^{-23}$	J/K
$2.083\,6618(19)\times10^{10}$	Hz/K
1.442 695(04)	bit
1	nat

Table 7.2: Abstract of appearances of Boltzmann's constant, relevant to Crenel Physics.

Like Boltzmann's constant, the 'heat capacity' of a body is also expressed as an amount of energy per degree temperature. In Metric Physics the heat capacity of a body is typically expressed in J/K. But in fact the appearance of this 'heat capacity' can be expressed in the entire variety of appearances (units of measurement) of Boltzmann's constant. In other words:

Boltzmann's constant is an objective/universal unit of measurement for the 'heat capacity' of a body.

Therefore, the 'nat' and the 'bit' –both being units of measurement for Boltzmann's constant- can serve as objective units of measurement for the 'heat capacity' of a body.

8. 'Entropy'.

This chapter introduces 'entropy'. Like 'temperature', the 'entropy' also is a statistical physical property of a 'body'.

The physicist Boltzmann linked properties of individual particles to properties that are associated with 'ensembles' (= large groups) of such particles. In the previous chapter such large group was named 'body'. The reason for this separate term is that the particles that together compose a body must be detectable on a one-by-one basis. In an 'ensemble' this is not necessarily required, hence the differentiation.

Entropy is defined through Boltzmann's equation:

$$S = k_B . \ln(w) \qquad (8.1)$$

This equation relates the number of possible microscopic states 'w' in which the particles of a body might reside to a macroscopic physical property named 'entropy', symbol '*S*'. In the equation symbol 'k_B' is Boltzmann's constant as discussed in the previous chapter. *Equation (8.1) is only valid for cases where all individual states have equal probability.*

- From a 'body' perspective (at its macro scale) and in SI units of measurement the entropy '*S*' can be expressed in J/K. In such case 'k_B' is found equal to:
  $k_B = 1.3806488 \times 10^{-23}$ J/K.
  See table (7.1) for other appearances of k_B.
- From a 'particle' perspective (at micro scale) the appearance 'entropy' of a body is synonym with 'information entropy'. Here the 'entropy' represents the amount of information that is required to fully describe a body's instantaneous status, that is: the state of each of its individual particles. Note that this requires particles to be detectable on a one-by-one basis. Also note that the number of states in which an individual particle might reside is presumed to be a natural number. Thanks to statistics one does not need to know in what particular status (e.g. status 'A', or 'B', or 'C', etc.) each individual and particular particle resides: it is sufficient to quantify the pallet of options.

When the entropy is reviewed from this micro scale perspective, the unit of measurement for the aforementioned 'amount of information' is the 'nat' (= logarithm base e or 'natural logarithm', hence the name 'nat'). Boltzmann's equation (8.1) then translates into:
$S = \ln(w)$.
Whereby k_B= 1 'nat' =1: thus this constant is not shown in the equation. Boltzmann's constant thereby inherently is normalized to numerical value 1: k_B = 1 'nat').
Boltzmann's constant can also be expressed in 'bit' (= logarithm base 2), whereby: 1 'nat' = 1/ln(2) 'bit', see Table (7.1). This conversion will be discussed later.

There is a logical reason for the logarithmic relationship that appears in Boltzmann's equation (8.1). To study this, the concept 'object' will be introduced here:

An 'object' is composed of a limited number of components. This number is limited to the point that the contribution of each individual component is relevant.

This differentiates an 'object' from the earlier defined 'body' (where the impact of an individual particle is statistically irrelevant). Other than a 'particle' in a 'body', a 'component' of a 'body' does not need to be detectable on a one-by-one basis.

The different terminologies are sown below:

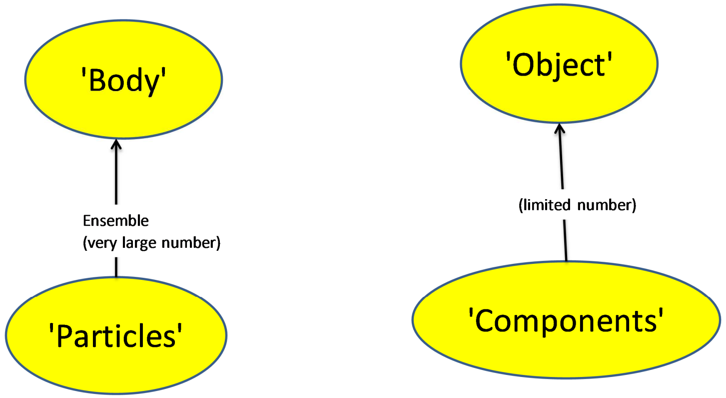

Figure (8.1): definition of terminologies.

Consider an object that contains only one single component, and that this object resides in a simple environment: a one dimensional binary space. A binary space is a space where each dimension has 2 states, e.g. represented by a '0' and a '1'. Because this space is 1-dimensional it takes only one parameter to fully describe the object's status (representing the one dimension in which the single underlying component can reside). This parameter then can have only two values (representing the two possible states '0' and '1' of the component). It takes exactly 1 'bit' of information to describe such object's status within this space, while per the above equation such object's entropy equals ln(2) 'nat'.

This explains the conversion factor 'ln(2)' between the 'nat' and the 'bit' as unit of measurement for Boltzmann's constant: the inherent constraint of a 'bit' is that its 'state' can only be binary, that is: either 'true' or 'false' (typically expressed as '1' and '0' respectively). Hence relative to the 'nat' the 'bit' is logarithm base 2 rather than natural logarithm.
Note: in case the single component could resign in 10 different states (per dimension) its state would be represented by logarithm base 10 (sometimes called the 'dit').

Now consider the aforementioned single component to reside e.g. in a '4'-dimensional binary space. To represent the number of states in which it could reside, one would need 4 bits of information: one for each dimension. E.g. state '0100' would be a valid (= complete) status specification. The number of possible states would be 2^4, whereby '2' presents the number of states per dimension, and '4' represents the number of dimensions. Now consider 2 components in that same space. Each of these two can reside in 2^4 states, such that the combination of the two can reside in $(2^4)^2$ different states. More in general, in this space the combination of 'n' components can reside in $(2^4)^n$ states. Thereby, the term 2^4 can be considered a 'space property': its value is strictly depending on the 'number of dimensions in the space' (here: 4) and the 'number of states per dimension' (here: 2). Within the entire space this 'space property' is presumed equal. In relation to equation (8.1) this 'space property' can therefore be represented by a fixed dimensionless number 'X':

$$X = (\#S)^{(\#D)} \tag{8.2}$$

Whereby:
#S = the 'Number of States per Dimension'
#D = the 'Number of Dimensions'

In such space, an n-component object then coincides with X^n states. The number of possible states therefore –regardless what 'X' may be- grows *exponentially* with the number of contained components. Equation (8.1) can be further detailed as follows:

$$S = k_B\, ln(X^n) = k_B.n.\ln(X) \tag{8.3}$$

This equation shows that the appearance entropy 'S' of an object grows proportionally with the number of contained components 'n'. Consequently:

> **if two bodies A and B each have entropy, the combining of body A and B into a larger body C results in an entropy that equals the summation of the entropy values of its individual parts.**

Equation (8.3) can be further detailed, using Equation (8.2):

$$S = k_B.n.\#D.\ln(\#S) \tag{8.4}$$

Whereby:
#S = the 'Number of States per Dimension'

#D = the 'Number of Dimensions'
n = the 'number of components'

Consequently:

> **the entropy of a body is proportional to the number of dimensions of the space in which it resides.**

As mentioned, to apply Boltzmann's equation (8.1), (8.3) or (8.4) it is required that each possible state has equal probability. A system that meets this requirement is called 'micro-canonical'. For systems that are not 'micro-canonical' equation (8.1) is enhanced to the more general equation:

$$S = -\sum p_i \ln p_i \tag{8.5}$$

Where 'S' is the 'information entropy' (expressed in 'nats') and 'p_i' is the probability at which the state with index 'i' occurs.

> To verify consistency between Equations (8.1) and (8.5), assume a particular micro-canonical system with 4 possible states whereby $p_1=p_2=p_3=p_4=0.25$. Note that the summation of all individual probabilities always must equal 1, thus in case of 4 equal probabilities each individual probability must have the value 0.25. For such system the equations (8.1) and (8.5) indeed produce an equal result:
>
> $$\text{S} = \ln(4) = 4 \times \big(-0.25(\ln(0.25)\big) = 1.386294\ \ 'nat' \tag{8.6}$$
>
> Likewise, for e.g. a micro-canonical system with 5 possible states: $p_1=p_2=p_3=p_4=p_5=0.2$. Again, equations (8.1) and (8.5) produce equal result:
>
> $$S = \ln(5) = 5 \times (-0.2(\ln(0.2)) = 1.609438\, 'nat' \tag{8.7}$$

In general, equation (8.5) matches equation (8.1) regardless the number of states, provided that all state probabilities are equal. In cases where the individual probabilities are not equal, a lower entropy value will be found per equation (8.5), and equation (8.1) is not applicable.

In the extreme case per above binary example, the probability of state '1' could e.g. be '0', and chances on state '0' would than by implication equal '1' (or vice versa). In such extreme probability case the object's entropy would by implication have a value 0 'nat'.

a) Entropy makes step-changes.

The nature of equation (8.4)…

$$S = k_B.n.\#D.\ln(\#S)$$

… does not allow the entropy of a micro-canonical object to have just any positive real numerical value. In this equation parameter k_B is a natural constant with the value of 1 'nat'. The other parameters *n, #D* and *#S* are natural numbers (1, 2, 3, etc.). For micro-canonical objects the entropy value therefore climbs in steps ΔS as any of these natural numbers increases. Thereby the dependency on *#S* (the number of states per dimension) is logarithmic.

The question at hand is: what is the magnitude of the smallest possible –non-zero- entropy step change ΔS for such object?

Equation (8.4) shows that an object of which the components can only reside in one possible state per dimension (or: parameter #S = 1) has an entropy of 0 because ln(1)=0. This is regardless the number of contained components or number of dimensions. Such object with entropy=0 would not be able to interact with anything because any interaction requires a status change of at least one component within the body, and here such change is not possible. Such object therefore might exist in theory, but it would be undetectable: no sensor can sense anything without having the possibility to interact. Therefore the minimum value for entropy for a detectable object requires that its contained components can reside in at least 2 possible states per dimension. That requirement is expressed through the following constraint:

$$\#S \geq 2 \tag{8.8}$$

Furthermore, in order to find a non-zero value for entropy, the number of dimensions of the space in which the body resides should

at least be 1, as specified by the following constraint:

$$\#D \geq 1 \tag{8.9}$$

Finally, entropy has no physical meaning unless there is at least one component contained within the body. Therefore:

$$n \geq 1 \tag{8.10}$$

Based on equation (8.4) and the above constraints the minimum possible entropy step change therefore equals:

$$\Delta S_{min} = k_B.1.1.\ln(2) = k_B.\ln(2) \tag{8.11}$$

Because in this equation k_B = 1 'nat', which equals 1/ln(2) 'bit", equation (8.11) can be enhanced as follows:

$$\Delta S_{min} = k_B.\ln(2) = 1'nat'.\ln(2) = 1\,'bit' \tag{8.12}$$

Thus:

> **The 'bit' is the smallest possible step change in the entropy of a micro-canonical body.**

In order to verify the above, consider a row of 10 coins. Each coin has two possible states (head or tail), with equal probability. The entropy can be calculated by using equation (8.4) whereby:

k_B = 1 'nat',
n = 10 (because there are 10 coins)
#D = 1 (because the row represents only one dimension)
#S = 2 (because each coin has two possible states)
Thus,

$$S = 1\,('nat').10.1.\ln(2) = 10\,'bit'$$

The next higher level of entropy then is:

$$S_{next\ higher} = S + \Delta S_{min} = 10\,'bit' + 1'bit' = 11\,'bit'$$

It thereby is presumed that this larger object -with the minimum next higher level of entropy- still has the same number of dimensions

(#D = 1), and that per dimension the number of states is still the same (#S = 2). Equation (8.12) then shows that –without changing 'space' properties- this next higher level of entropy is achieved by replacing n=10 by n=11. In other words: the next higher level of entropy is given by a row of 11 coins. The extra coin adds 1 'bit'. This is in line with the expectations.

b) Minimum entropy, the 'entropy-atom'.

With 1 'bit' being the minimum step change in entropy, the question is whether an object that contains an entropy of 1 'bit' could possibly exist and be detected in an otherwise empty space.

Conservation laws dictate that within a universe any change must be compensated, and within a single bit object (thus: single component object) there is no option for compensation. Therefore the minimum entropy of such isolated object must be based on the next higher level of entropy (relative to a single component object). That is: twice the value of a minimum entropy '∆S' per equation (8.12). Thus, an observable object encompasses two status parameters that can mutually interact.

This leads to:

$$S_{min} = 2.\|\Delta S_{min}\| = 2.k_B.\ln(2) = 2.'nat'.\ln(2) = 2\,'bit' \quad (8.13)$$

Or:

The minimum entropy of a detectable isolated object equals 2 'bit' or 2.ln(2).'nat' or ln(4).'nat'.

Inherent to the mechanism of interaction between two components within an object is the drive towards a micro-canonical state. Per equation (8.5) the consequence of a status change of one of the components within the object would demand equal compensation per conservation laws. It would require some other component to simultaneously switch status in a reverse direction, thereby exactly compensating the initial change such that the body's over all status remains unaffected. This demand not only requires that an object contains at least two components, but also

that the probabilities between the various statuses and between the various components match. This demand is the driving force that makes the individual components within an object to seek equal probability between statuses. Or: conservation laws are the driving force for the object (as a whole) to seek the micro-canonical status. Or: these laws thereby inherently make the individual object to seek its maximum entropy level: the micro-canonical case. Or: an observable object with minimum entropy is 'de facto' an object that contains two 'binary components' that each can 'flip-flop' (= change status from 1 to 0, or back from 0 to 1). Conservation laws dictate that this 'flip-flop' per component cannot take place independently on the time scale of the external observer: at the instantaneous moment where one component 'flips', the other must 'flop', and vice versa. This demand is non-relativistic, and it sets the object's minimum entropy value equal to all. To the observer, the rate of 'flip-flopping' is however a relative observation which –amongst others- depends on the pace of his clock relative to the object. In fact the external observer could measure this rate, whereby his sensor would impact the observed 'flip-flop' frequency. Under circumstances he can reconcile what this frequency was before the measurement took place. He would associate this reckoned frequency with the Package containment prior to the interaction.

Such object of minimum entropy (2 bits) comes close to the originally intended meaning of the word 'atom', as proposed by early philosophers. Typically, the search for the smallest possible (indivisible) particle focusses on 'mass' content or 'energy' content. What we have here however is the quantification of minimum entropy (or: minimum complexity) for a detectible object.

In conclusion:

The smallest possible detectable object is 2-bit and micro-canonical. It will be named 'entropy-atom'.

As an object contains more components (= bits), its likelihood to exist will be smaller due to a higher complexity. It is postulated that the detectable (tangible) world is composed of 'entropy-atoms'.

c) ***Entropy is an objective property.***

Boltzmann's constant k_B, expressed in 'nat' or 'bit', is an objective unit of measurement, and the other parameters in equation (8.4) are non-relativistic natural numbers. Therefore:

> **The 'entropy' of a micro-canonical body is a non-relativistic (objective) property: its value is equal between all observers.**

The entropy of such a body can be compared to e.g. the size of a computer memory which also is expressed in 'bits': such memory size is equal to all observers. One consequence is that computer memory operations (and thereby calculations) lead to objective –non-relativistic- results, regardless the circumstances of the observer relative to a computer. Another conclusion is that the heat capacity of a micro-canonical body (which also can be expressed in 'bits') also is a non-relativistic property: it is equal to all. It is the 'temperature' property of a body that is the relativistic component in determining its Package containment.

With the 'entropy-atom' being defined as the minimum possible detectable object, there is an argument to postulate that it is the smallest possible (or: elementary) object to which macroscopic laws can be applied. Examples of macroscopic laws are Newton's laws and the gravitational force.

The indivisible property of 'entropy-atoms' justifies a re-scaling of Boltzmann's constant based on their universal entropy value of 2 bits:

$$\|k_B\| = \frac{k_B}{2.\text{'bit'}} = \frac{k_B}{2.\ln(2)} = \frac{1\ \text{'}nat\text{'}}{\ln(4)} \tag{8.14}$$

Here, $\|k_B\|$ is the normalized Boltzmann constant (expressed in 'nat'), whereas 'k_B' is Boltzmann's constant as found in Metric Physics: k_B= 1 'nat'. The conversion factor equals 1/ln(4). The introduction of this rescaling factor thus relates the numerical value Boltzmann's constant to truly observable objects rather than to the number of 'micro-states' in which an object can reside. Such observable objects

are subject to macroscopic laws. Therefore, the re-scaling of Boltzmann's constant by introducing a factor 1/ln(4) ensures a connection at base level between Boltzmann's constant (= 1 'nat'), tangible objects ('entropy-atoms'), and macroscopic laws.

d) ***Introduction of the Package appearance 'InformationTemperature'.***

The temperature scale (or: its unit of measurement) is based on Boltzmann's constant, see chapter 7 equation (7.5):

$$1^0\ T_{CP} = \frac{1\ Package}{k_B} \tag{8.15}$$

As discussed, Boltzmann's constant is associated with the various Package appearances: there is one unit of measurement (and associated numerical value) per Package appearance, see table (7.1). The reverse of this association also holds: per appearance of Boltzmann's constant there is an associated appearance of the Package.

The first implication of the above is that the usage of the normalized Boltzmann constant in Crenel Physics per equation (8.14) leads to the following equation for the 'entropy-atom' based temperature scale in Crenel Physics:

$$1^0\ T_{CPEA} = \frac{1\ Package}{\|k_B\|} = \frac{1\ Package.\ln(4)}{k_B} \tag{8.16}$$

The subscript '*CPEA*' refers to: Crenel Physics Entropy-Atom based temperature scale. It differs by a factor ln(4), as can be seen by substituting (8.15) in (8.16):

$$1^0\ T_{CPEA} = \ln(4)\ \times 1^0\ T_{CP} \tag{8.17}$$

Or:

$$1^0\ T_{CP} = \frac{1}{\ln(4)} \times 1^0\ T_{CPEA} \tag{8.18}$$

As discussed in the previous paragraph, the relevance of this revised temperature scale is that it is based on the smallest possible observable object (as opposed to being based on the mathematical concept of 'states' per Boltzmann's equation for 'information entropy').

Rather than using this new temperature scale ${}^{0}T_{CPEA}$, instead the original temperature scale ${}^{0}T_{CP}$ will be used in the following. Per equation (8.17) this requires a multiplication of the temperature ${}^{0}T_{CP}$ with a factor ln(4).

There must be an associated additional appearance for the Package. To find this, Equation (8.15) can be rewritten as follows:

$$1\ Package = \ln(4) \times\ 1^{0}\ T_{CP}\ \times\ k_B$$

$$= \ln(4) \times\ 1^{0}\ T_{CP}\ \times 'nat' \qquad (8.19)$$

Thus, the unit of measurement for this additional Package appearance equals '(nat.ln(4)).${}^{0}T_{(CP)}$'. Thereby:

> '${}^{0}T_{(CP)}$' is the temperature of the object, expressed in ${}^{0}T_{(CP)}$, which unit of measurement is equal to the Planck temperature.

For conceptual reasons such additional Package appearance requires a name:

> **The Package can appear as 'InformationTemperature' which is expressed in '(nat.ln(4)).${}^{0}T_{(CP)}$'. The symbol 'Inf-T' will be used.**

One can envision this Package appearance of an object as follows: it is the amount of information (expressed in 'Entropy-Atoms') that is required to define the detailed state of the object, multiplied with the object's temperature based on the Planck temperature scale, or: the number of smallest possible detectable components that together compose an object (= 2 bits), multiplied with the temperature of that object (whereby the Planck-Temperature is the unit of measurement).

9. A review of Package appearances.

The Package appearances –and their respective Metric Physics units of measurement- discussed so far are:

1. Energy (expressed in Joules)
2. Mass (expressed in kg)
3. Angular frequency (expressed in rad/s)
4. InformationTemperature (expressed in ('nat'.ln(4)).K)

The conversion factors for the first 3 appearances were derived in chapter 5, and are shown in the following figure:

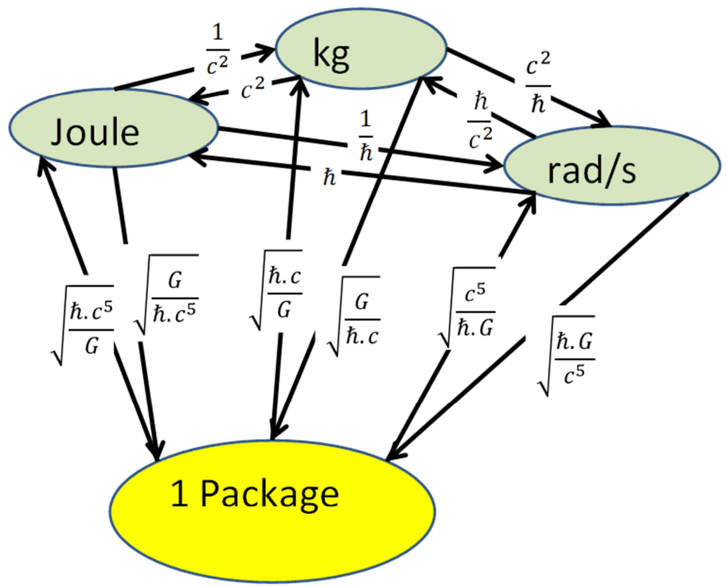

Fig. 9.1: conversion between Package and various appearances.

Figure (9.1) shows a network with 4 'nodes': the 'Package', the 'Joule', the 'kg' and the 'rad/s'. One can now 'walk' through this network, from node to node. If one starts at some selected node, follows the arrows along some random path and thereby ends at the same (starting) node, the multiplied value of all encountered conversion factors equals the dimensionless value 1, as should logically be expected.

The conversion factor for converting Packages into its new appearance InformationTemperature has not yet been addressed. In Crenel Physics (see equation (8.19)) the unit of measurement for InformationTemperature was found equal to:

$$\ln(4) \times 'nat' \times {}^{0}T_{(CP)}$$

Thus:

$$1\,Package = \ln(4) \times 'nat' \times 1\,{}^{0}T_{(CP)}$$

The Metric Physics counterpart is to be expressed in ('nat'.ln(4)).K, which then ensures that the InformationTemperature scale coincides with the Metric Kelvin temperature scale. This unit of measurement can be derived by converting $T_{(cp)}$ into K, and multiplying the result with a factor ln(4).'nat':

$$ConversionFactor = \ln(4) \times 'nat' \times 'X' \qquad (9.1)$$

Whereby 'X' is the conversion factor from $T_{(cp)}$ into K.

The complication of this task is that 'X' is based on Boltzmann's constant, while for each Package appearance there is an associated appearance for this constant. In Metric Physics these are –as was discussed so far- respectively the J/K, kg/K, Hz/K. Based on the definition of temperature (see equation 7.4)…

$$1^{0}\,T_{CP} = \frac{1\,Package}{K_{B(CP)}}$$

…these various versions of Boltzmann's constant define as many equations for converting $1^{0}T_{(CP)}$ towards 1 K. The following three associated conversion factors were derived (see equations (7.7) and (7.8)):

$$1^{0}\,T_{(CP)} = \sqrt{\frac{\hbar.c^{5}}{G.(k_B)^{2}}}\;K \qquad \left(k_B\ in\ {}^{J}/_{K}\right) \qquad (9.2)$$

$$1^{0}\,T_{(CP)} = \sqrt{\frac{\hbar.c}{G.(k_B)^{2}}}\;K \qquad \left(k_B\ in\ {}^{kg}/_{K}\right) \qquad (9.3)$$

$$1^{0}\,T_{(CP)} = \frac{1}{2.\pi}.\sqrt{\frac{c^{5}}{\hbar.G.(k_B)^{2}}}\;K \qquad \left(k_B\ in\ {}^{Hz}/_{K}\right) \qquad (9.4)$$

Each of these equations leads to the Kelvin, provided that Boltzmann's constant is substituted in the associated unit of measurement, and that the natural constants are expressed in base units of the Metric system. E.g. light velocity 'c' is to be entered in m/s, etc.. Furthermore, the equations (9.2), (9.3) and (9.4) all result in that 1 $^{0}T_{(CP)}$ corresponds to 1.4168 x 10^{32} K, which is equal to the 'Planck temperature'.

By substituting one of the equations (9.2), (9.3) or (9.4) into equation (9.1) the Metric Physics conversion factor from 1 Package into 1 unit of measurement for InformationTemperature is found. The choice between these three equations then depends on the discussed appearances of Boltzmann's constant in Metric Physics, which were J/K, kg/K or Hz/K respectively:

$$1\,Package =$$

$$= \ln(4) \times 'nat' \,.\sqrt{\frac{\hbar.c^{5}}{G.(k_B)^{2}}} \qquad \left(k_B\ in\ {}^{J}/_{K}\right) \qquad (9.5)$$

$$= \ln(4) \times 'nat' \,.\sqrt{\frac{\hbar.c}{G.(k_B)^{2}}} \qquad \left(k_B\ in\ {}^{kg}/_{K}\right) \qquad (9.6)$$

$$= \ln(4) \times 'nat' \times \frac{1}{2.\pi}.\sqrt{\frac{c^{5}}{\hbar.G.(k_B)^{2}}} \qquad \left(k_B\ in\ {}^{Hz}/_{K}\right) \qquad (9.7)$$

When based on J/K per equation (9.5), the conversion factors between various appearances and the Package are as shown in the figure below:

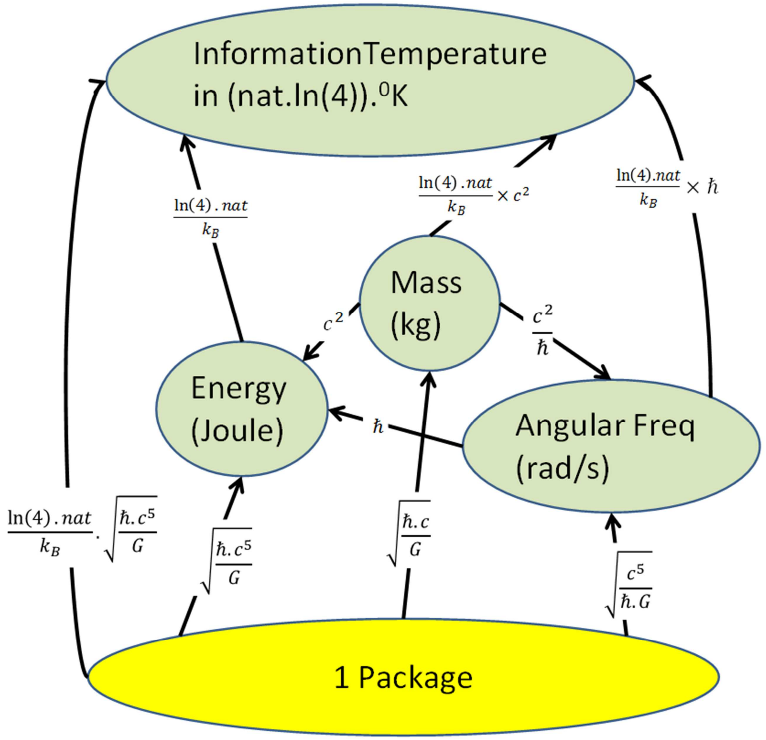

Figure 9.2: conversion factors based on Boltzmann's constant being expressed in J/K.

For clarity only the conversion into one direction is shown (the conversion into the opposite direction is the reciprocal). If the conversion factors are based on Boltzmann's constant being expressed in Hz/K, figure (9.2) would be as follows:

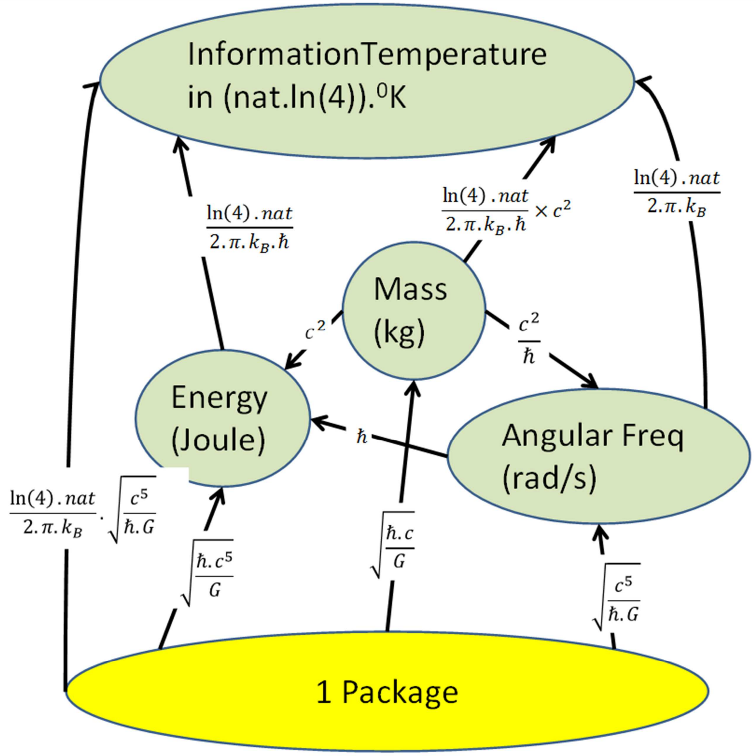

Figure 9.3: conversion factors based on Boltzmann's constant being expressed in Hz/K.

Although in figures (9.2) and (9.3) for each node the Metric units of measurement are shown, these conversion factors are valid in *any* system of units of measurement in which the appearances 'mass', 'energy', 'angular frequency' and 'InformationTemperature' are in use. Or: the figures show *objective* physical relationships between these 4 appearances and the Package.

The reason why these relationships are objective is that these are based on natural constants only.

In retrospect it turns out that Crenel Physics is a shortcut towards a model that is based on Planck units, with the Package as the underlying basis. Thereby the number of Packages that is contained by a certain –observable- object can have various appearances that are named and quantified as follows:

1. A Package containing object can appear as 'mass'.
   The yardstick for numerical value of this appearance is the **'Planck-mass'**.
2. A Package containing object can appear as 'frequency'.
   The yardstick for numerical value of this appearance is the **'Planck-frequency'**.
3. A Package containing object can appear as 'energy'.
   The yardstick for numerical value of this appearance is the **'Planck-energy'**.
4. A Package containing object can appear as 'InformationTemperature'.
   The yardstick for numerical value of this appearance is the number of **'Entropy-Atoms'** that is contained within this object, multiplied with the **'Planck-Temperature'** of this object.

Two postulations are inherently embedded in the approach of Crenel Physics:

1. **A physical relationship between appearances must be based on a relationship between fundamental properties (here: Crenel and Package). Such relationship thereby can be reflected between all appearances thereof.**
2. **A physical relationship found in a lower dimensional physical model remains valid when new dimensions are added.**

As an example, consider Newton's law: $\vec{F} = m.\vec{a}$.

Firstly, it must be seen as a relationship between appearances of the Package and the Crenel. E.g. symbol 'm' in the equation represents the 'mass' appearance of the Package. One can replace this mass appearance by e.g. the frequency appearance or the energy

appearance or the InformationTemperature appearance of the object, using the correct conversion factors (that all are based on natural constants only, and therefore objective). After such replacement the above equation still holds. The first postulation explains e.g. why photons –like masses- curve in a gravitational field.

Secondly, because this law is found valid in a 1-dimensional spatial space, it must also be valid in a 3-dimensional spatial space and in a 10-dimensional spatial space. In Metric Physics terms: in this example one only needs a single spatial dimension to identify the underlying conceptual physics. It is then postulated that within a spatial space of higher dimension that same physical principle still holds.

Through the normalization procedure that is followed in Crenel Physics, the velocity of light 'c' has been normalized to the dimensionless value 1. Thus the 'energy' appearance and the 'mass' appearance melted into one single physical concept. This normalization simplifies Einstein's equation $\mathbb{E} = m.c^2$ towards $\mathbb{E} = m$.

Thus, in Crenel Physics the light velocity becomes a dimensionless 1. The point here is that –despite such normalization- all physical laws remain valid, although some might snow under.

Whereas normalization to dimensionless unity inherently leads to snowing under physical relationships that actually would appear to exist, a reverse de-normalization process cannot make a found relationship disappear. Consequently: *should* a relationship be found in a –partially- normalized system of units of measurement, that relationship remains valid when the normalization procedure is reversed towards a system with more dimensions, e.g. towards the Metric S.I. units of measurement.

As a consequence of the Crenel Physics normalization procedure, figure (9.3) can be simplified to a lower dimensional model as follows:

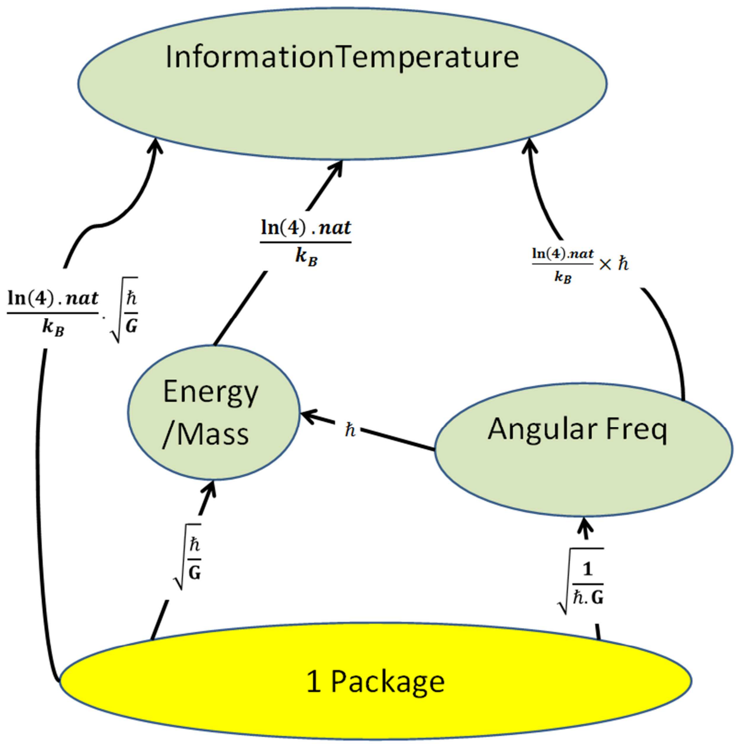

Figure 9.4: conversion factors between appearances, light velocity normalized to 1, Boltzmann's constant expressed in Energy unit of measurement/Temperature unit of measurement.

Figure (9.4) is valid for any system of units of measurement, in which the light velocity has been normalized to a dimensionless 1. Likewise, for e.g. the frequency appearance of Boltzmann's constant figure (9.3) can be simplified as follows:

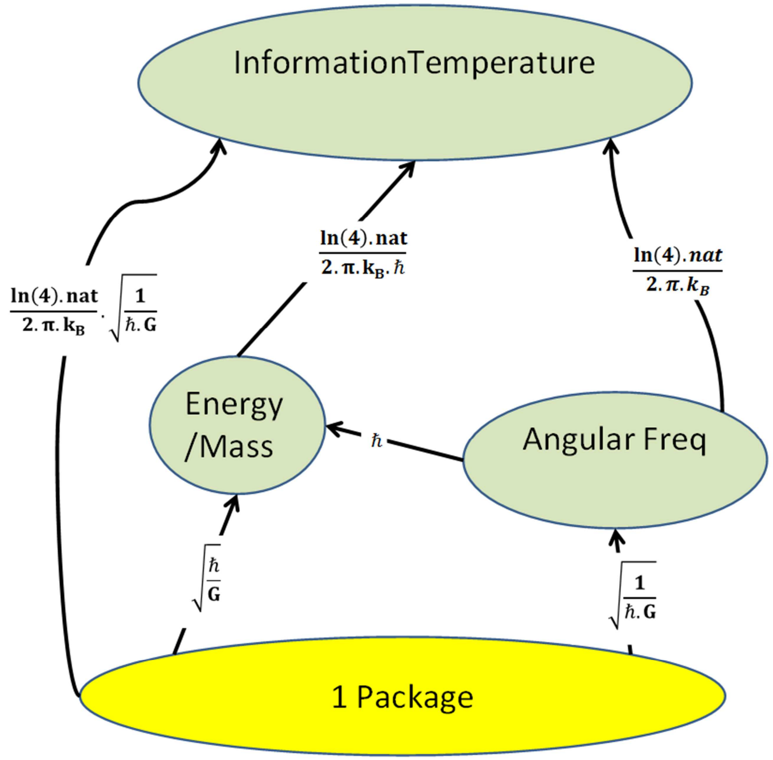

Figure 9.5: conversion factors between appearances, light velocity normalized to 1, Boltzmann's constant expressed in frequency unit of measurement/Temperature unit of measurement.

In Crenel Physics, such normalization of light velocity towards unity has been applied. However, Planck's constant '*h*' is expressed in P.C (Package times Crenel), and the gravitational constant '*G*' is expressed in C/P. Thus, Crenel Physics does not normalize these natural constants to unity: the properties (or: units of measurement) Crenel and Package have been introduced and maintained as two separate properties or dimensions. This is why these natural constants still show in figures (9.4) and (9.5).

Technically, if one would normalize every physical property to dimensionless unity, there would be no observable physical relationships left.

10. Conclusions.

Chapter (8) introduced the 'entropy' of a body:

$$\boldsymbol{Entropy} = \frac{\boldsymbol{Energy}}{\boldsymbol{Temperature}} \tag{10.1}$$

This equation is valid in any system of units of measurement, including Metric Physics and Crenel Physics. It defines a numerical relationship between three physical properties of a body: body entropy, body contained energy and body temperature. From a dimensional analyses point of view –regardless the actual 'body' at hand- equation (10.1) sets relations between the three units of measurement for these three properties. This relationship is reflected in the following equation:

$$\boldsymbol{1\ Unit\ of\ Entropy} = \frac{\boldsymbol{1\ unit\ of\ Energy}}{\boldsymbol{1\ unit\ of\ Temperature}} \tag{10.2}$$

Chapter 7 introduced Boltzmann's natural constant 'k_B'. This constant has as many appearances as there are Package appearances. See e.g. equations (7.6) and (7.8) whereby the 'energy' and 'frequency' appearances of the Package were addressed, and the associated appearances of Boltzmann's constant were derived. The found relationship between the latter (the multiplication factor 'h') was verified in Metric Physics through equation (7.9). It is essential that the relationships between various appearances of Boltzmann's constant are based on universal natural constants only: this ensures that the relationship between these appearances is objective, equal to all.

Furthermore a *mathematical* connection was identified when it comes to Boltzmann's constant: in Metric Physics the Boltzmann constant can –amongst others- be expressed in 'nats': k_B = 1 'nat', see table (7.2). The 'nat' stands for logarithm base 'e'. Like the mathematical constant 'π' comes forth from a mathematical procedure, so does the 'nat'. Therefore like 'π' and 'e', the 'nat' is objective: it is equal to all. The 'bit' is a related mathematical property that also is equal to all: 1 'bit' = ln(2) 'nat'. The 'bit' is a well-known measure for binary information storage capacity: the smallest possible memory storage equals 1 'bit'.

All users –regardless their systems of units of measurement- have the option to set Boltzmann's constant equal to the 'nat'. The choice to share this normalized value of k_B = 1 'nat' between various systems of units of measurement is optional: another option could e.g. be that one user decides to normalize Boltzmann's constant to the 'bit'. But once 'k_B' is settled, this inherently settles the scale (=unit of measurement) of dependent properties, in particular the 'temperature scale' (see Chapter 7). In conclusion: both Metric Physics as well as Crenel Physics settled Boltzmann's constant to equal 1 'nat'.

In chapter (8) the 'Entropy-Atom' was introduced as the 'atom' in its original philosopher's definition of 'indivisible object'. It led towards an initial re-scaling of Boltzmann's constant (and thereby the temperature scale), such that its numerical value related to 'true' observable objects rather than to the mathematical concept 'number of states' as per Boltzmann's equation $S=k_B.\ln(w)$.

It then was 'decided' to not rescale Boltzmann's constant (and thereby the temperature scale).The advantage is that in Metric Physics the degree K THUS can remain in usage, while in Crenel Physics the unit of measurement for temperature remains the Planck temperature. As a consequence however, the conversion factor 'ln(4)' needs to be carried around as in equation (10.3):

$$1^0\ T_{CP} = \frac{1\ Package.\ln(4)}{k_B} \qquad (10.3)$$

Again, the 'Package' in this equation can have various appearances: 'energy', 'mass', 'frequency' etc., and pending the selected appearance the associated version of Boltzmann's constant has to be used.

In chapter (9) the relevance of the partial normalization procedure – as followed in Crenel Physics, by only setting the velocity of light to unity- was reviewed. It condensed into figures (9.4) and (9.5).

By selecting e.g. the 'energy' appearance of the Package, per Figure (9.4) the conversion factor for 'Package' equals: $\sqrt{\frac{\hbar}{G}}$ such that the unit of temperature per equation (10.3) becomes:

$$1^0\ T_{CP} = \sqrt{\frac{\hbar}{G}}\ \frac{\ln(4)}{k_B} \qquad (10.4)$$

This result can be substituted into equation (10.2), whereby the 'unit of energy' still needs conversion towards the 'Package'. This requires a conversion factor $\sqrt{\frac{G}{\hbar}}$ such that equation (10.2) can be written as:

$$1\ 'nat' = \frac{\sqrt{\frac{G}{\hbar}}}{\sqrt{\frac{\hbar}{G}} \times \frac{\ln(4)}{k_B}} = \frac{k_B \times G}{\hbar \times \ln(4)} \qquad (10.5)$$

This equation is valid in any system of units of measurement, provided that the 'energy' appearance of Boltzmann's constant is used. In Metric Physics this requires the J/K appearance.

There also is the requirement that the relationship between the 'frequency' property and the 'energy' property of an object is set on the same basis. The latter is not so between Metric Physics and Crenel Physics. In chapter 4 the 'Package' was defined as an object with an angular frequency of 1 radial per Crenel. Or:
$'Package\ content' = \hbar.\omega$.

> The advantage of opting for this selection (in Crenel Physics) was that all conversion factors (towards units of measurement in any other system) match the well-known 'Planck' units of measurement. Had, instead of the angular frequency, the orbit frequency been selected, a factor of $2.\pi$ would have been introduced. This would de-facto have been reflected by replacing all 'reduced Planck constants' (symbol: $\hbar$) in all subsequent equations by the regular 'Planck constant' (symbol: h).

In Metric Physics, through Planck's equation $\mathbb{E} = h.\upsilon$ the relationship between 'energy' and 'frequency' is however based on frequency, and not 'angular frequency'. Therefore, in equation (10.5) the reduced Planck constant (symbol $\hbar$) needs to be replaced with Planck's constant (symbol h):

$$1\ 'nat' = \frac{k_B \times G}{h \times \ln(4)}\ (note: k_B\ in \frac{J}{K}) \qquad (10.6)$$

Equation (10.5) holds for any system of units of measurement, whereby Planck's constant is 'angular frequency' based, and equation (10.6) holds for systems where Planck's constant is 'frequency' based (such as in the Metric system). Furthermore, as stated, in equation (10.6) the 'energy' appearance of Boltzmann's constant is to be used. In the Metric system that means that Boltzmann's constant is to be expressed in J/K.

With reference to Figure (9.5) the 'frequency appearance' of equation (10.6) can also be derived, using the associated conversion factors, and using the 'frequency' based appearance of Boltzmann's constant (in Hz/K):

$$1\ 'nat' = \frac{k_B \times G}{\ln(4)} \qquad (note: k_B\ in \frac{Hz}{K}) \qquad (10.7)$$

11. Verification.

At its bottom line, Crenel Physics uses fewer dimensions (or: units of measurement) relative to Metric Physics. However, through conversions –whereby Planck units of measurement are the conversion factors- a higher dimensional Physical model can be produced through the concept of 'appearances'. In fact, the entire Metric Physics pallet of units of measurement can be constructed in a consistent manner: Planck's $\mathbb{E} = h.\upsilon$, Einstein's $\mathbb{E} = m.c^2$ and Boltzmann's S=k_B.ln(w) all form the basis for engineering forward and backward between Crenel Physics units of measurement and Metric Physics units of measurement.

The remarkable outcome of this integration is that Metric Physics appears over-dimensioned in terms of the number of natural constants. Natural constants supposedly are completely independent to each other. Equations (10.6) and (10.7) however demonstrate a relationship between k_B, G and h. Note, that there are as many versions of this relationship as there are appearances of Boltzmann's constant: the two given equations are just examples based on two appearances (energy and frequency).

The equations can be verified by entering the Metric Physics values for the shown natural constants:

h = 6.62606957 * 10^{-34}	(J.s)
G = 6.67384 * 10^{-11}	($N.m^2kg^{-2}$)
k_B= 1.3806488 * 10^{-23}	(J/K) …. For equation (10.6)
k_B= 2.0836618 * 10^{10}	(Hz/K).. For equation (10.7)

Substitution of these values into the equation (10.6) or into the equation (10.7) both results in a value of 1.0031, rather than in a value of 1. Or: assuming that the natural constants 'h' and 'k_B' are known at high precision, the then calculated value for G per equation (10.6) or (10.7) is 0.3% below the value as actually found in literature. At this point no explanation has been given for the difference.

Such explanation could possibly be found in the following considerations:

1. the found relationship is based on the entropy of the smallest possible detectable object in an otherwise empty space, rather than on the number of states that can be found in such an object.
2. space itself is found to compress under the influence of gravity: perhaps the gravitational constant might also be subject to its own impact. This would be an effect that relates to the compression of spatial dimensions under the impact of gravity.
3. particles of smallest possible entropy are not exactly 2 bits as postulated,
4. the associated ‘Entropy-Atoms’ are not the only ‘atoms’ that compose our universe.
5. Etcetera.

The understanding of the whereabouts of the above undershooting of the numerical value of the gravitational constant by 0.3% is of critical importance for claiming that an unambiguous relationship between the aforementioned natural constants has been found.