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Crenel Physics

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1. Summary.

This manuscript starts by raising some questions about our Metric system of units of measurement. For editorial reasons it then continues by describing the efforts of a 'Martian' (so to speak) to set up a grass roots system. He thereby is coached by 'Professor Earth', who makes sure that findings of earthly giants (in particular Einstein, Planck and Boltzmann) are properly integrated.

Relative to Metric units of measurement, the outcome is overwhelmingly simple and consistent. Thereby, the gravitational constant '*G*' is found to equal:

$$G \equiv \frac{h.\,ln(4)}{k_B}$$

This finding –obviously- is of fundamental importance. It is however only valid between elementary particles. For ensembles thereof a –slightly- higher value for '*G'* must be expected.

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2. Introduction: Units of Measurement versus Dimensions

In Metric Physics the 'meter' (symbol 'm') is a 'base unit of measurement'. It is used to measure 'distance', which is a one-dimensional physical property. That same 'meter' is also used to measure the surface of an object, expressed in m^2, thus a two-dimensional property. The volume of an object is in m^3, which is three-dimensional. The human envisioning is limited to three spatial dimensions, but there is no argument against modeling an extrapolation towards higher dimensions: m^4, m^5, etc.

In general:

> *With one single 'unit of measurement' one can span an endless number of 'dimensions'.*

Combinations of different units of measurement also span dimensions. E.g. velocity is expressed in 'm/s', acceleration in 'm/s^2'. Both 'm/s' and 'm/s^2' are dimensions. Mathematically 'm/s^2' means: meters divided by seconds squared. No one can envision a 'square second'. No one knows how to divide a 'meter' by such a 'square second'. Yet the ratio m/s^2 is used routinely and one can envision acceleration. There is no limit to the number of potential combinations here. Furthermore, in concept, it is irrelevant whether one can or cannot envision the combination.

> *Any combination of 'units of measurement' shapes a 'dimension'.*

In Metric Physics 'units of measurement' show overlap. Consequently a dimension is not necessarily exclusively linked to a specific combination. To explore this, consider Newton's equation

$$F = m.a. \tag{2.1}$$

The equation demands that the dimension at the left side of the equal sign (here: force '*F*', expressed in Newton, symbol 'N') is equal to the dimension at the right side (here: mass 'm' in 'kg' times acceleration 'a' in 'm/s^2', which is expressed in $kg.m/s^2$). Thus, the dimension of the unit of measurement 'N' is equal to the dimension '$kg.m/s^2$'.

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> *In the Metric system of units of measurement, a single and unique 'dimension' can be represented by various combinations of units of measurement.*

Based on equation (2.1) one may wonder why the 'N(ewton)' was introduced as a measure for force, if this force also can be expressed in '$kg.m/s^2$': clearly a 'N' and a '$kg.m/s^2$' *are* the same.

What were the criteria to introduce the Newton as a measure? In comparison to the above example: why was no dedicated unit for e.g. velocity introduced (which could e.g. be named 'speeds')? In this particular case one kept using the 'm/s'. Neither is there a dedicated unit of measurement for acceleration (which could e.g. be named 'accelerations'): here one kept using the 'm/s^2'. Where is the consistency in introducing units of measurement? In general: shouldn't one use a leanest possible set of 'units of measurement', thereby avoiding any overlap?

This fundamental question will be addressed in the following chapters. Thereby, for editorial reasons 'professor Earth' is introduced. He will coach the 'Martians' (so to speak) in their effort to setup their grass roots system for units of measurement.

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3. Base Units of Measurement, introducing the 'Package' and the 'Crenel'.

The Martian showed his polished piece of rock. "We can use this as our base unit to measure 'mass'", he proposed. "We can make as many copies as we need, and from here onwards let's measure 'mass' in 'rocks'". Professor Earth realized that Martian traders would be happy with the initiative. He also realized that on earth a likewise approach was followed. Nevertheless he said: "Well, let's park that idea for a moment".

"Did you think about 'energy' already?" professor Earth then asked. "Yes, I did" said the Martian, who continued: "each full revolution of my windmill over here produces the exact same amount of energy. So I plan to measure energy in 'windmill revolution equivalents'".

"Well, I've got news for you" said professor Earth. "In case you decide to use 'rocks' to measure mass and 'windmill revolutions' to measure energy, as a spin-off you thereby inherently defined both the numerical value *and* the unit of measurement of light velocity in vacuum". The Martian looked surprised and then asked: "What does the velocity of light in vacuum have to do with my 'rock' and my 'windmill revolutions'?"

Professor Earth explained that Einstein found:

$$\mathbb{E} = \mathrm{m}.c^2 \tag{3.1}$$

Consequently, if the unit of measurement for mass 'm' is 'rocks' and energy '$\mathbb{E}$' is measured in 'windmill revolutions', per equation (3.1) the velocity of light 'c' in vacuum equals:

$$c = \sqrt{\frac{energy\ of\ 1\ windmill\ revolution}{mass\ of\ 1\ Rock}} \tag{3.2}$$

The Martian realized the huge impact of Einstein's equation –right at the very beginning of his task. "Are you sure about $E=m.c^2$?" he asked. "Absolutely: on earth we do convert mass into energy, e.g. in our nuclear reactors. And vice versa we can convert energy into mass, e.g. in our particle accelerators. Thereby we indeed found the conversion factor to equal c^2" the professor said. "The validity has been confirmed in numerous ways."

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To document this finding, the Martian took a pencil and drew the following figure:

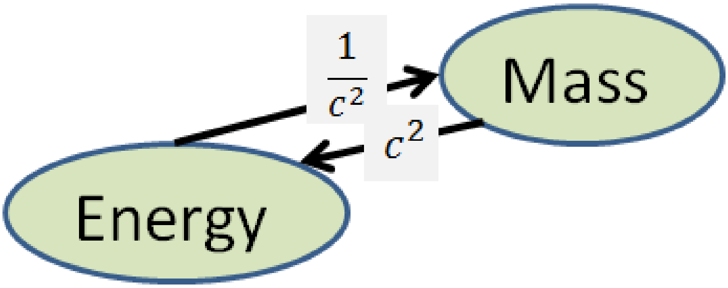

Fig. 3.1: Einstein's relation between the Mass unit of measurement and Energy unit of measurement.

It showed that the units of measurement for 'mass' and 'energy' can be converted to and fro. Therefore, his current proposal seemed like introducing two currencies on Mars (e.g. the $ and the €): currencies can also be converted to and fro. However, if he would have to introduce currency on Mars, he certainly would *not* consider introducing more than one...

He reviewed the conversion factor 'c^2' (and thereby 'c') in equation (3.1). Should this conversion factor be subject to changes, either in due time or pending location or circumstances, this would have consequences. In such case one could create energy from nothing by converting it into mass, then wait patiently until 'c' has a higher value, and then reconvert this mass back into energy. Or the opposite way: one could let energy disappear into nothing by waiting until 'c' decreases. However, both scenarios would be in conflict with the 'conservation principle'. This 'conservation principle' dictates that -at the bottom line- nothing can be gained or lost. Or: if one sees a parameter grow or shrink, such is always the result of transformation(s) that exactly counterbalance the change. Based on the 'conservation principle' the Martian concluded that 'c^2' (and thereby 'c') must be constant in due time and past history. A likewise violation would occur, should 'c^2' be subject to change that is caused by any other physical parameter, such as location, vicinity of a black hole, or anything at all, no matter how exotic.

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Or: ‘c’ must be a ‘universal natural constant’. The paramount implication thereof is that although there might be numerous sets of units of measurement around, the ‘velocity of light in vacuum’ must be equal to all and therefore can be used as a shared anchor point. In evaluating equation (3.2) he recognized that in his Martian case (so far) the numerical value of c must be 1, and its unit of measurement equal to:

$$\sqrt{\frac{energy\ of\ 1\ windmill\ revolution}{mass\ of\ 1\ Rock}} \qquad (3.3)$$

But professor Earth also mentioned that ‘c’ represented a ‘velocity’: the velocity of light in vacuum. Typically he would –like Earth people- prefer to express velocity as a ratio between some unit of measurement for ‘distance’ and some unit of measurement for ‘time’ (on Earth that is: m/s). Neither of these units was introduced yet. But clearly, in any case such preference would lead to overlap with the unit of measurement that he already found for velocity per equation (3.3). Before jumping to conclusions, the Martian asked professor Earth whether a connection between Einstein’s equation (3.1) and ‘distance’ or ‘time’ can be found. “Sure! That would be Planck’s equation...

$$\mathbb{E} = h.\upsilon \qquad (3.4)$$

...the professor responded. “Thereby, ‘$\mathbb{E}$’ is the same energy as used in Einstein’s equation $E=m.c^2$, ‘h’ is Planck’s universal natural constant, and ‘υ’ is the frequency which is expressed in ‘1/time-unit’ or ‘(time units)$^{-1}$’, that is: the inverse of ‘time units’. Planck’s equation applies to elementary particles, such as photons. But one can enhance its application to e.g. electrons etc.”

The Martian now enhanced his figure as follows:

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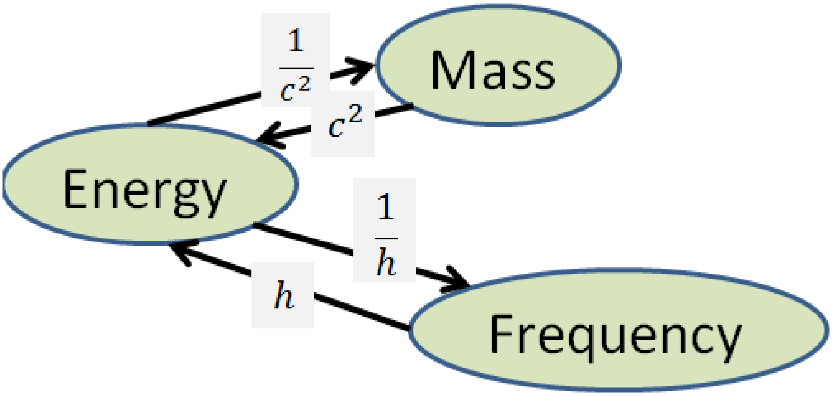

Fig. 3.2: addition of Planck's relation between Energy and Frequency.

Professor Earth continued. "In other words: equation (3.4) embeds a connection between 'energy' and 'time': the relationship between 'Frequency' units of measurement and 'Time' units of measurement is entirely based on a mathematical procedure: inversion. The invert of 'x' is '1/x', and vice versa the invert of '1/x' is 'x'. Likewise, the time unit of measurement is the inverse of the frequency unit of measurement, and vice versa."

Again, the Martian enhanced his figure accordingly:

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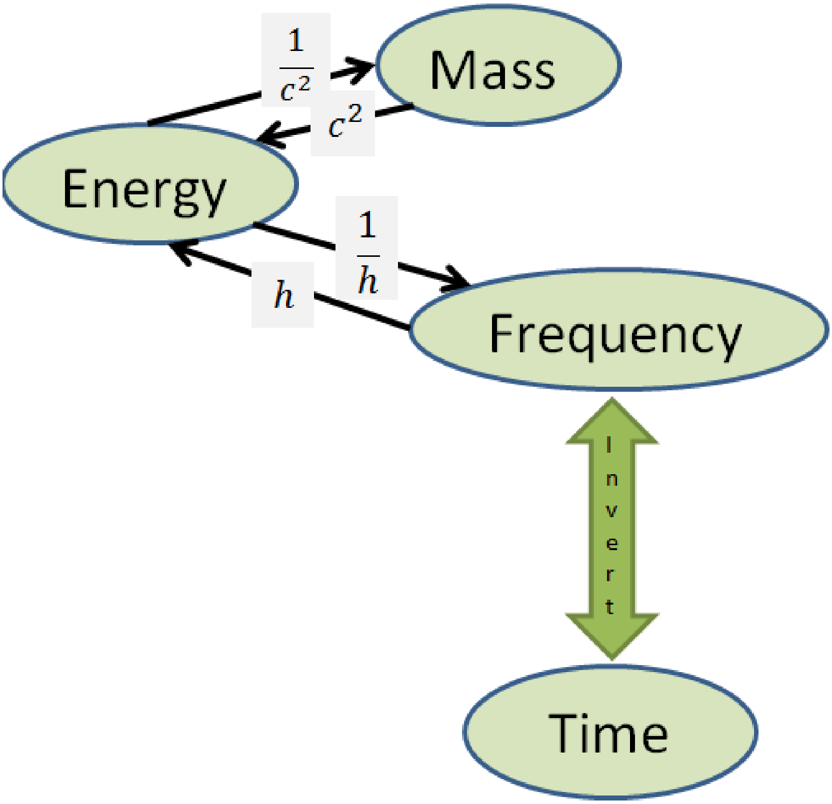

Figure 3.3: the 'Time' unit of measurement is the inverse of 'Frequency' unit of measurement.

He then reviewed figure (3.3) and concluded that –at this point- he had a 'chicken and egg' problem: the unit of measurement for Planck's constant '*h*' obviously would be the unit of measurement for energy ('windmill revolution') divided by the unit of measurement for frequency. And because the unit of measurement for frequency is the inverse of the unit of measurement for time, that would boil down to expressing 'h' in the unit of measurement for energy *multiplied* with the –yet to determine- unit of measurement for 'time'. Consequently: by postulating a numerical value for Planck's constant, he would implicitly set the unit of measurement for 'time' relative to 'energy', and vice versa.

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To get some guidance, the Martian asked how –on Earth- this issue was tackled. Professor Earth answered: "We defined the 'second' as a unit of measurement for time. We –finally- based it on a periodic process that we found in some atom. Any physical process that we monitor seems in sync with this periodic atomic process. Once the 'second' was set, and already having a unit of measurement for 'energy' (the Joule, symbol 'J'), that settled the numerical value of Planck's constant. Obviously our approach does lead to a long number with many digits: $6.62606957 \times 10^{-34}$ J.s.".

Based on this input, the Martian wondered what would be his leanest possible way forward to find a periodic process which then could be used as a measure for time. Then his eye fell on the windmill. It seemed to be running at constant rate, although he had no clue how one could possibly verify that. What he did know was that other physical processes seemed in sync with the windmill. Obviously (for the sake of our case) Mars has a very stable climate with steady winds. E.g. he found the number of windmill revolutions between two sunrises to be equal every day. And a full orbit of Mars around the sun also took an equal amount of windmill revolutions, again and again.

He then figured out a strategy to avoid unnecessary complexity: avoid extra hardware. He therefore decided that one revolution of the windmill represents not only a measure for energy, but simultaneously it sets a time scale. Thus, the windmill in this dual function 'de facto' represented Planck's equation (3.3): it relates 'time' (end thereby 'frequency') to 'energy' in a fixed ratio. Or: one revolution always produces an amount of energy exactly equal to 1 'windmill revolution', whereas it always –based on the windmill's physical properties- takes an amount of time equal to 1 'windmill revolution' to achieve that.

There still was the option of defining that it would take two (or any other real number) windmill revolutions to define one time unit. Or perhaps it might be wise to use radials of windmill revolution ('angular frequency') rather than full revolutions ('frequency') as a basis. Whatever he would decide here: it would be OK in concept. For now he decided to stick to a value of 1 revolution for a time unit. Thereby his only argument was that this would save battery power (and brain power) in future calculations. Consequently –at least for the time being- on Mars Planck's constant received the value of 1 (windmill revolution of energy x windmill revolution of time).

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By having proposed a standard for 'time' measurement, in combination with his knowledge that the light velocity in vacuum 'c' is equal to all, the logical and leanest possible way to define a unit of measurement for 'distance' was obvious now: let light travel through vacuum during the time it takes to complete one revolution of the windmill. The distance covered represents the demanded yardstick. Thus one unit of 'distance' would be defined as: one unit of time multiplied with the velocity of light 'c'. He enhanced his figure accordingly as follows:

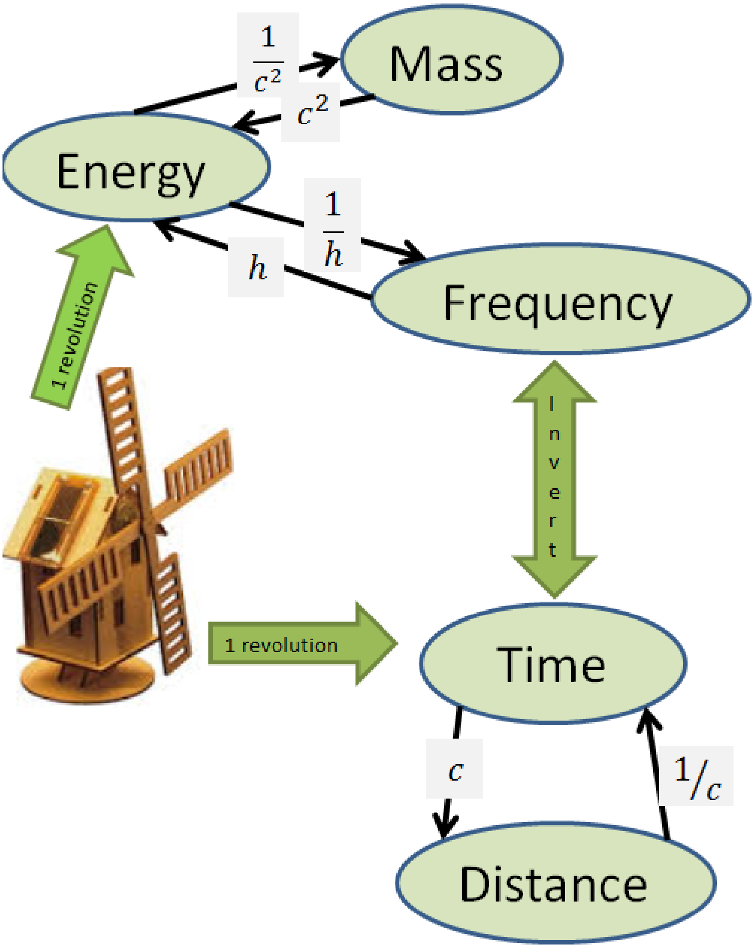

Figure 3.4: the 'windmill' based system of Units of Measurement.

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In reviewing figure (3.4), the Martian noticed to his surprise that he did not need his polished piece of rock anymore. At this point the windmill, Einstein (via 'c') and Planck (via 'h') defined 'mass', 'energy', 'frequency', 'time', and 'distance' in an unambiguous manner. That is: the Martian now indeed had an unambiguous standard for each of these.

Do I really need the windmill, he started to wonder. Without windmill, all aforementioned Units of Measurement would be floating around, although mutually tightly related to each other via natural constants 'c' and 'h', and also by a mathematical procedure called 'inversion', as shown in figure (3.4). And yes: to achieve the unambiguous mutual relationships between his five units of measurement he needed to fix Planck's constant 'h' himself, whereby he had –without strong argument- decided for the value of 1 (windmill revolution of energy x windmill revolution of time).

To find an answer, the Martian envisioned figure (3.4) without the windmill. Thereby –to his surprise- he had to admit that unwillingly he had been biased by professor Earth: "Why on Earth did I presume that figure (3.4) shows 'units of measurement'?" he asked professor Earth. He continued: "Indeed, the figure shows some of the 'base units' from the Metric system. But doesn't the figure also show that these units of measurement are related to each other in an unambiguous manner? Isn't this like introducing the $ *and* the € to express the economic value of an object, whereby –in the case at hand- the exchange rate is universally fixed?". "Affirmative!" he concluded.

The Martian continued: "Therefore, unlike the Metric system says, figure (3.4) does *not* show 'base units of measurement'. It actually shows 'dimensions' of more fundamental physical properties that must lie underneath."

Professor Earth agreed that this was a convincing proposition. Together they reviewed figure (3.4) to see if there was some additional structure. Thereby they identified two clusters:

1. the cluster energy/mass.
   These dimensions reflect the 'content' of an object.
   They are mutually and unambiguously related to each other through 'c^2', whereby 'c' is a 'universal natural constant'.

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2. the cluster time/distance.
   These two dimensions reflect the 'whereabouts' (or where/when) in terms of space and time.
   They are also unambiguously connected through that same 'c'.

Finally, they identified in figure (3.4) that both clusters are connected to each other via the dimension 'frequency' and a mathematical procedure: 'inversion'. Here Planck's constant 'h' came into the picture. The clusters 'Content' and 'Whereabouts' present themselves as the 'Yin and Yang' of physics. Thereby Yin and Yang are not opposite, but reciprocal to each other.

"Considering the aforementioned base Metric units of measurement to be dimensions of something more basic underneath is typical for your model", professor Earth responded. "One inherent feature is that through Planck's constant and a mathematical procedure named 'inversion' the 'content' dimensions can be converted into 'whereabouts' (or: space/time dimensions), and vice versa. In concept this allows detectable particles to suddenly appear/disappear in an apparently empty space, without the conservation principle being violated."

Professor Earth knew that –indeed- some advanced physical theories did allow detectable particles to appear and disappear, apparently out of the bleu. But wisely he did not mention it here, to avoid complicating the Martian's thinking process.

Again, the Martian enhanced his notes to reflect the current status of his model:

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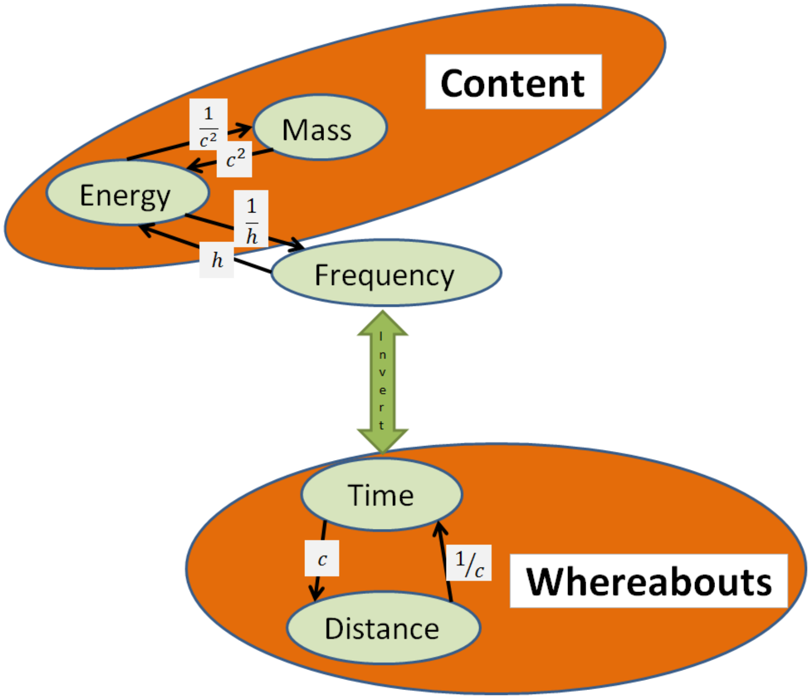

Figure 3.5: two clusters of dimensions.

The Martian did not yet give names to the two new base units of measurement that were presumed to lie under both respective clusters. He decided:

1. The **'Package'** (symbol 'P') will be the unit of measurement for 'content'. Content can reveal itself as either 'energy' or 'mass' (and perhaps additional dimensions).
   Thus, in the model 'energy' and 'mass' will both be measured in the newly introduced unit of measurement 'Package'.

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2. The **'Crenel'** (symbol 'C') will be the unit of measurement for 'whereabouts'.
   (The name 'Crenel' was inspired by the shape of crenellation on top of castle walls: this shape represents the binary function, the most elementary graphical representation of an elapsing process.)
   Thus, the dimensions 'time' and 'distance' will both be expressed in the unit of measurement 'Crenel'.

In order to avoid confusion in terminology, it was decided to name the currently proposed model for units of measurement 'Crenel Physics', as opposed to 'Metric Physics'.

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4. Drilling down.

The Martian now concluded that in his Crenel Physics model 'velocity' is expressed in Crenel (in its distance dimension) per Crenel (in its time dimension). That makes velocity a dimensionless property. The numerical value of velocity 'de facto' represents a partial shift (or: an exchange) from the distance dimension towards the time dimension. Or: at constant velocity 'time' is traded for 'distance' at a constant rate. Thereby, no Crenels are gained or lost, thus obeying the conservation principle. This leaves just one option for the conversion rate between both dimensions (that is: for the numerical value of 'c' in figure (3.5)). It must equal 1 (dimensionless), which –in turn- is referred to as the 'mathematical unity'.

Furthermore, one cannot expect more than complete exchange from distance towards time. Such complete exchange corresponds to a velocity value of 1. Thus, the Crenel Physics model embeds a natural maximum to the exchange, and thereby to velocity: value 1. The Martian thus noted for the value of the universal natural constant 'c':

$$c_{CP} = 1\ (dimensionless) \tag{4.1}$$

The subscript '*CP*' in (4.1) thereby refers to the Crenel Physics version of this natural constant.

If 'time' is expressed in Crenel, 'frequency' is expressed in the inverse: 'Crenel^{-1}'. Figure (3.5) shows how to convert 1 Package from the 'content cluster' towards the 'whereabouts cluster' (expressed in Crenel):

1. Convert to the 'Energy' dimension (when needed),
2. Multiply with Planck's constant 'h' (this will produce the 'frequency' dimension, which is Crenel^{-1}),
3. Invert (which produces the 'time' dimension in Crenel).

Therefore, in the Crenel Physics model the dimension of Planck's constant '*h*' equals Package x Crenel. Thereby the Martian had decided –yet for no specific reason other than saving battery power in computers- that the numerical value of '*h*' equals 1. He noted:

$$h_{CP} = 1\ P.C \tag{4.2}$$

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Again the subscript '*CP*' indicates that this is the Crenel Physics version of Planck's constant.

The Martian found that one key purpose of the currently identified 'universal natural constants' was: to serve as conversion factor between 'dimensions' of his basic units of measurement (the Package and the Crenel). The conservation principle demands such conversions to be unambiguously equal to all, anywhere, anytime, and under any circumstance. Therefore, these 'universal natural constants', together with 'mathematical procedures' (such as 'inversion'), are the only acceptable building blocks for any conversion factor between dimensions. He wondered what other purpose a 'universal natural constant' may possibly serve. He could not find any.

The mutual dependency between 'dimensions' and 'universal natural constants' was clear now. He already noticed that in the cluster 'whereabouts' the conversion factor 'c' (and its inverse) is used, while in the cluster 'content' the conversion factor 'c^2' (and its inverse) is used. From a mathematical perspective this 'c^2' is the next higher dimension of 'c'. Therefore, when e.g. in Metric Physics the value of 'c' is defined as light velocity in vacuum, through a measurement thereof one not only finds the value for a dimension conversion factor in the 'whereabouts' cluster, but –by taking the next higher (second power) of this value one also and implicitly finds the value of a conversion factor in the 'content' cluster. And this is so regardless the system of units of measurement one might be using. Is there a physical relevance to this?

Is –more in general- the 'Content' cluster a 2-dimensional version of the 'whereabouts' cluster, just like the 'm^2' is a 2-dimensional version of the 'm'? What could be the relevance of this?

> Imagine a square piece of plywood of 1 meter length and 1 meter width. Its surface is calculated as length x width = 1 x 1 = 1 m^2. Place it within a 2-dimensional Cartesian plane, whereby the yardsticks along the X-axis and the Y-axis are fully exchangeable: in Metric Physics both yardsticks are equal to the 1-dimensional meter. To meet the conservation principle, it is a requirement that the surface remains 1 square meter, regardless its orientation within the 2-dimensional plane.
>
> This demands that the dimensions X and Y are perpendicular

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to each other (or: orthogonal). Should X not be perpendicular to Y, the value of the surface would not be equal to length x width (it would be less), and furthermore it would change if one rotates the piece of plywood.

The above example relates to spatial coordinates. Here one can envision that dimensions X and Y are 'orthogonal'. In mathematical terms the above requirement can be generalized by representing each dimension as a vector, and by demanding that the inner product of these vectors equals 0. This eliminates potential interdependency between dimensions.

Thus the information as shown in figure (3.5) can be further enhanced. Based on the model in which 'Time' and 'Distance' are two independent dimensions of the Crenel, one can represent these dimensions as two orthogonal unit vectors, each with the unit-length of 1 Crenel. And likewise 'Energy' and 'Mass' can be represented by two orthogonal vectors, each having a unit length of 1 Package.

Mathematically these findings are expressed as follows:

$$\overrightarrow{Time}.\overrightarrow{Distance} = 0 \tag{4.3}$$

Whereby:

$$\left\|\overrightarrow{Time}\right\| = \left\|\overrightarrow{Distance}\right\| = 1\ Crenel \tag{4.3a}$$

And:

$$\overrightarrow{Mass}.\overrightarrow{Energy} = 0 \tag{4.4}$$

Whereby:

$$\left\|\overrightarrow{Mass}\right\| = \left\|\overrightarrow{Energy}\right\| = 1\ Package \tag{4.4a}$$

But figure (3.5) embeds even more information: the Crenel and the Package themselves, although –so far- envisioned as two separate 'base units of measurement', can in turn be drilled down on the basis that these can be converted into each other through an unambiguous procedure.

Therefore Crenel and Package share something more fundamental

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underneath. That 'something' underneath is a base-line in the current model, and therefore must logically be the 'most basic unit of measurement' that is thinkable: a dimensionless 1. This in turn is equal to universal natural constant 'c_{CP}'.

Again, based on the conservation principle the Crenel and Package dimensions must be orthogonal. As an enhancement to equation (4.2) (P.C=1), the complete result of this ultimate drilldown can be mathematically expressed as follows:

$$\overrightarrow{Package}.\overrightarrow{Crenel} = 0 \qquad (4.5)$$

Whereby:

$$\left\|\overrightarrow{Package}\right\| = \left\|\overrightarrow{Crenel}\right\| = 1 \qquad (4.5a)$$

The Martian enhanced his picture as follows:

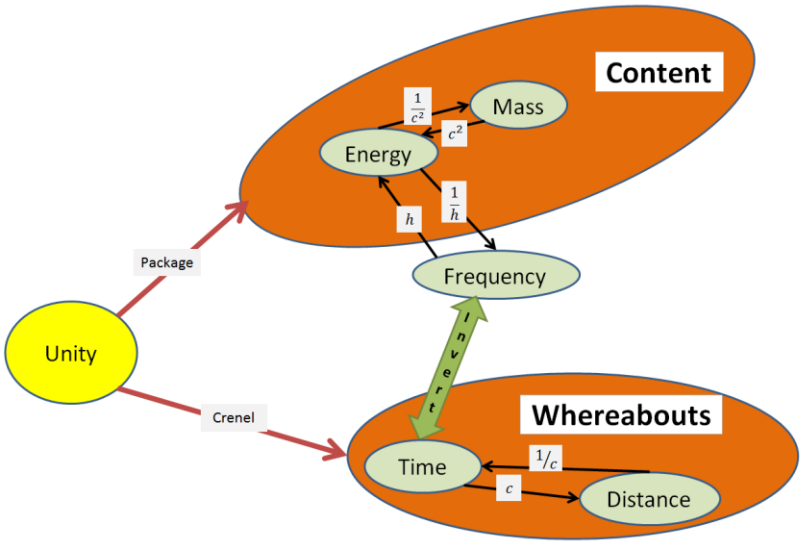

Fig. 4.1: Package and Crenel are dimensions of 'unity'.

Equation (4.5) ensures that neither the 'mass' nor the 'energy' that is contained by some object is subject to change just because of a relocation in the whereabouts of the object.

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5. Boltzmann and the 'Entropy Atom'

Figure (4.1) shows 'unity' as the base for a hierarchical structure of various dimensions.

The Martian asked himself whether the mathematical 'unity' really is a unique and single starting point. Indeed, one cannot further disassemble 'unity' (the dimensionless 1) into something more basic underneath. But would that feature make 'unity' the only starting point? How about a mathematical base unit for 'contained information'? Does it exist, and if so, could that possibly be a meaningful alternate or enhancement to the model?

He decided to consult professor Earth: "The concept of 'unity' delivers the possibility to count meters or seconds or kilograms or Joules or apples or pears or Crenels or Packages, but how about a measure for 'contained information'? Would you classify a unit of 'information' as a mathematical property (thereby universally shared), or is it a physical property (thereby perhaps not universally shared)?" Professor Earth associated 'information' with 'information storage' as it takes place in binary computers. Here, the storage capacity is measured in 'bits', regardless the nature of the information that these 'bits' actually represent: that information might be a number, or a text, or a pixel in a picture, etc.. At first sight there seemed no association between these 'bits', and the framework that the Martian was working on. However, where 'unity' is a concept that can be universally shared between all thinkable systems of units of measurement, so is the 'bit'. At the bottom line that's why binary computer calculations (such as addition or multiplication) will produce universally equal (that is: non-relativistic) results. That is: results regardless the 'whereabouts'. He answered: "To get to the roots of what we know about 'information', we must review Boltzmann's theory. This theory is condensed in Boltzmann's equation":

$$S = k_B . \ln(w) \tag{5.1}$$

"It specifies the entropy 'S' of a body. Entropy is a measure for a body's complexity, which in turn is a measure for its potential to reside in different states: the more complex a body is, the more options it has. Parameter 'w' equals the number of states in which a body can reside (expressed in 'unity'), and 'k_B' is a universal natural constant, rightfully named 'Boltzmann's constant'." The professor

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then gave a basic example:

> One can apply Boltzmann's equation (5.1) to a row of coins. Each coin can lay head-up or tail-up, which can be represented by symbol '1' and '0' respectively. Thus, each coin represents one 'bit' of information: the definition of a 'bit' is that it is 'something' that can reside in two states. A row of 2 coins can reside in 4 states (00, 01, 10 and 11). A row of 'n' coins can reside in 2^n states. In such case Boltzmann's equation becomes: $S = k_B . \ln(2^n) = k_B . n. \ln(2)$. This shows that entropy '*S'* grows proportionally with the number of coins '*n*'. Therefore 'entropy' is proportional to 'content', and thereby proportional to the Package. Thus, the Martian indeed had a point in raising the issue 'contained information' in relation to 'content'.

Professor Earth enhanced that in Metric Physics 'entropy' is expressed in a variety of units of measurement, ranging from macroscopic (such as J/K and Hz/K) to microscopic (such as 'bit' and 'nat'). Per unit of measurement there is an associated numerical value for Boltzmann's constant k_B. The –to Crenel Physics-most relevant values (as can be found e.g. in Wikipedia) are:

k_B	=	$1.3806488 \times 10^{-23}$	J/K
k_B	=	2.0836618×10^{10}	Hz/K
k_B	=	1.442695	bit
k_B	=	1	nat

The Martian was surprised by this variety of options (and the many more that can be found). Obviously, in all cases the same underlying physical fact is addressed. Consequently there must be an unambiguous relationship between all versions of k_B. Therefore he decided to explore this.

If one applies Boltzmann's equation to a row of coins, recognizing that each coin has two states, one ends up with the equation $S=k_B.n.\ln(2)$. The factor 'ln(2)' in the equation is in recognition of 'w' being equal to 2 when it comes to coins. One thereby uses the 'nat' as the unit of measurement for entropy, and therefore in this equation: $k_B = 1$ 'nat' (the 'nat' stands for the natural logarithm). Alternatively, one can express the entropy in 'bit'. In that case the equation simplifies to $S= k_B.n$, whereby k_B is to be expressed in 'bit'. This explains why k_B in 'nat' can be converted to k_B in 'bit' by applying the mathematical conversion factor 1/ln(2). The Martian

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found that indeed this conversion factor –as he expected- delivers the above listed value for k_B in bit: k_B = 1.442695041 bit. In fact his pocket calculator showed a few more digits than the listed value as found in Wikipedia.

The 'nat' and the 'bit' (and the conversion factor 1/ln(2) being mathematical properties, make these universally sharable between Metric Physics, Crenel Physics and –for that matter- with any other system of units of measurement. Therefore, besides '*c*' and 'unity', these are additional candidates to serve as universal anchor point in his model.

To next explore the relationship between the above mathematical (and microscopic) scales 'nat' and 'bit' at the one side, and the physical (macroscopic) scales 'J/K' and 'Hz/K' at the other, the Martian first needed to introduce a unit of measurement for 'temperature' in Crenel Physics (symbol: T_{CP}). This T_{CP} will then be the counterpart of the Kelvin (K). He discussed the concept of a 'temperature scale' with professor Earth. He thereby found that the Metric Physics approach to define one unit of temperature is as follows:

$$1^0\ T = \frac{Unit\ of\ measurement\ for\ Energy}{k_B} \tag{5.2}$$

Thereby, to ensure dimensional integrity, k_B is to be expressed in energy units of measurement (Joule) divided by the temperature unit of measurement (Kelvin).

The Martian decided to follow the same approach. In his Crenel Physics model the Package is the unit of measurement for energy. Thus, equation (5.2) translates to:

$$1^0\ T_{CP} = \frac{Package}{k_B} \tag{5.3}$$

Via this definition of the 'Temperature' scale, the Crenel Physics model unambiguously connects microscopic entropy to macroscopic entropy. Key thereby is that the temperature scale is –through k_B- implicitly and at bottom line based on the 'nat', which is a mathematical property. This made the Martian aware of two remarkable points:

> Because the 'nat' is a universal yardsticks for entropy, any other unit of measurement for entropy, regardless whereabouts, also must be universal. Thus, where both Joule and Kelvin are properties that are relative to the observer (or: the observed Joule and Kelvin are subject to the theory of relativity), their ratio J/K or Hz/K is not (!).
>
> In metric Physics the 'heat capacity' of a body also is expressed in J/K. Heat capacity therefore is another measure for 'complexity'. Consequently, the heat capacity of a body is a non-relativistic property that must be found equal between observers.

With the 'nat' identified as the universal starting point for information, he raised a new fundamental question: what does it take to facilitate exchange of information, e.g. between particles? The Martian thereby reasoned that one only can observe a particle if one receives information about it, thus from it.

Per conservation principle it would be impossible for an isolated particle to transmit information, unless such is compensated. Or: if one assumes the observable particle to be isolated and self-sustaining, this compensation requires a change of some internal parameter(s). The search for the smallest possible particle that can meet this demand should therefore focus on a particle's minimum required complexity, rather than on e.g. a minimum required Package containment in terms of 'mass' or 'energy'. He decided to start his search for a minimum complexity level from the bottom up. Rock bottom would be a single state particle. Per Boltzmann's equation the entropy of a single state particle equals 0, because in such case 'w' = 1 and ln(w)=ln(1)=0. Such particles might exist, but –as individual entities- these will not be able to transmit information: the conservation principle associates such transmission with an internal status change, and these entities cannot change their status. Therefore –if existing- single state particles are undetectable. Therefore he had to scale up. The next higher option would be a particle that can reside in two different states that can be represented by a '1' and a '0'. Again: although particles with such a low complexity might exist, one would nevertheless not be able to detect these. This is because none of its internal parameters (there is only one here) could change to compensate information transmission (or: external communication), and thus the conservation principle cannot be obeyed. Such one-bit particles can only be detected if they are combined into pairs. Therefore, an isolated minimum detectable particle must represent an entropy/complexity/heat capacity of at

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least *two* bits. Thus, when one bit 'flips' (as part of some information transmission process), the other bit can 'flop' to compensate.

> *The Martian decided to name the minimum detectable particles 'entropy-atoms', whereby their entropy equals 2 bits, which is equal to 2.ln(2) or ln(4) 'nat'.*

With the smallest possible detectable particles now being universally quantified in terms of entropy/complexity/heat capacity, he evaluated the following proposal: *Detectable particles (and thereby the entire detectable universe) are constructed of minimum detectable particles, that is: of entropy-atoms.* On second thought this proposal did not seem right: particles that have a complexity of three bits (rather than two) cannot and should not be excluded from the model: a 3-bit particle cannot be split into smaller separate parts that each would be detectable. However, a four-bit particle can –in terms of complexity- be thought to be composed of two 2-bit entropy atoms. Therefore, the above statement is an over-simplification. While the Martian might –alternatively- name entropy-atoms 'bi-bits', recognizing that these are the simplest possible detectable entities, he now also recognized 'tri-bits' as particles with the next higher level of complexity/entropy. Thus he enhanced the above proposed statement as follows:

> *Any detectable object is composed of 'bi-bits' and/or 'tri-bits'.*

But how could one differentiate between a 'bi-bit' and a 'tri-bit'? In both cases the transmitted information is a bit-stream at some rate. He decided to park this question for now. But regardless the answer, according to the model, entropy/complexity/heat capacity is quantified. Per above statement it starts at 2 Bit, and thereafter can grow in discrete steps of 1 Bit (or ln(2) 'nat'). Like the 'entropy atom', these quanta are non-relativistic, equal to all, and therefore universally shared between all systems of units of measurement.

He thus concluded:

The entropy/complexity/heat capacity '*S*' equals:

$$S\ (in\ Nat) = \ n.k_B.\ln(2) \quad ,n \geq 2 \qquad (5.4)$$

whereby k_B = 1 ('nat'), which is equal to a dimensionless 1.

In case k_B is expressed in Bits, the entropy/complexity/heat capacity

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is accordingly expressed in Bits, and is equal to:

$$S\ (in\ Bits) = n.k_B \quad ,n \geq 2,\ (k_B = 1\ Bit) \tag{5.5}$$

In the Crenel Physics model, per equation (5.3), to find the Package content of a single entropy-atom (n=2), one must multiply the entropy value of such particle with its temperature, expressed in ${}^{0}T_{CP}$. E.g.: one entropy-atom (n=2), having a temperature of 1 ${}^{0}T_{CP}$ (temperature unit of measurement per equation 5.3) contains 1 Package.

Thus, besides the earlier found dimensions 'Mass' and 'Energy', the Martian now had a third dimension for 'Content'. He decided to name it 'Information Temperature', and enhanced his Crenel Physics model as follows:

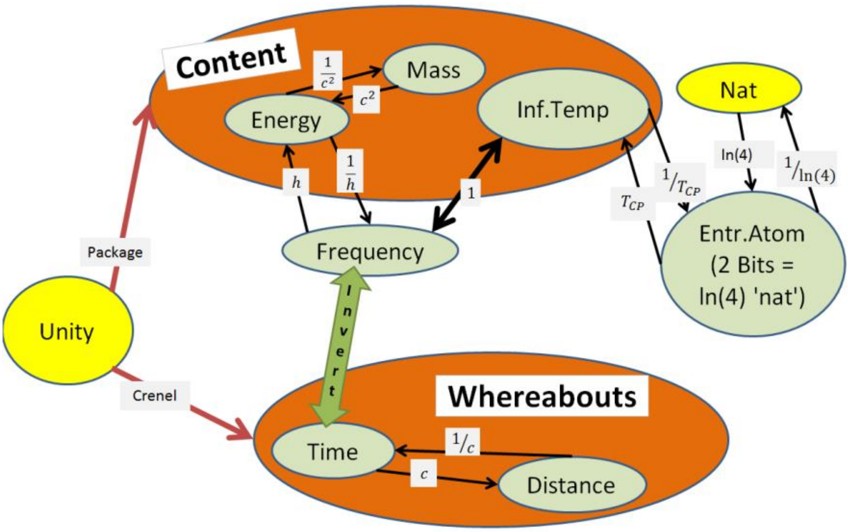

Fig. 5.1: 'Information Temperature' as a new dimension of 'Content'.

Thereby the temperature T_{CP} of an entropy-atom is not to be confused with the macroscopic temperature of a macroscopic object.

> A body composed of an *ensemble* of entropy-atoms will have an entropy value that expectedly will be *more* than just the summation of the individual entropies. The reason being, that within such body the entropy-atoms themselves will

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have extra degrees of freedom (can have various states) relative to each other (as opposed to being 'frozen' into some crystal structure). Per Planck's equation such will introduce extra 'ensemble-entropy' that is to be associated with a macroscopic 'ensemble-temperature'.

It was time to lean back for a moment, and to review the efforts so far. Professor Earth had started his input to the Martian by stating that the setting of measures for 'mass' and 'energy' implied the definition of velocity of light in vacuum 'c'. He also stated that such implication is universal, regardless the system of units of measurement. The Martian now reviewed figure (5.1) and concluded that *all* dimensions –so far- were tightly related to each other via universal natural constants or via mathematics. Figure (5.1) just gives the broader picture. It must apply to *any* system of units of measurement, including Metric Physics.

Professor Earth had followed the progress of the Martian with interest. One thought came up with regards to the 'Big Bang' theory: perhaps, prior to the 'Big Bang' the universe consisted of undetectable particles, in the Crenel Physics model described as 'single state particles' and/or 'mono-bits'. The 'Big Bang' could then be envisioned as a sudden process whereby 'mono-bits' grouped into pairs ('bi-bits'). Such envisioning would then allow the 'Big Bang' to take place while the conservation principle is obeyed. Key of this envisioning is that the 'Big Bang' would then mark the instance where particles became detectable, and thus started to interact. It would certainly mark the beginning of 'gravity' and –perhaps- thereby make the associated dimensions based on 'content' and 'whereabouts' become apparent (rather than 'created'). Again, the professor wisely did not mention it here, to avoid complicating the Martian's ongoing thinking process.

6. Gravitational constant and conversion factors

In Metric Physics, gravity is described as the attracting force between two masses:

$$F = G.m_1.m_2/d^2 \qquad (6.1)$$

From a Crenel Physics perspective 'mass' is a dimension of the Package. The Martian now wondered whether the gravitational force is 'mass'-based or whether it is 'Package'-based. The latter option provides a broader basis for the gravitational force to be induced.

When he discussed this with professor Earth, they considered photons. These bend their path in gravitational fields. Therefore their 'mass' dimension truly exists. At the same time this dimension is proportional to the energy containment and/or frequency appearance of the photon at hand. Thereby it is not relevant which of the aforementioned photon's properties one decides to measure: one can convert the result per Einstein or Planck and conclude that all dimensions are equally and simultaneously applicable, and unambiguously related to each other via universal natural constants. This inherently answered the above question: the gravitational force is induced by the Package containment of an object, regardless how that containment reveals itself (or: regardless the dimension of the Package that one decides to measure).

Equation (6.1) applies to any observer and any system of units of measurement. The Martian therefore substituted the Crenel Physics units of measurement for F, m_1, m_2 and d^2 into this equation. This resulted in the value for the Crenel Physics version of the gravitational constant '*G*':

$$G_{CP} = 1 \ \frac{C}{P} \qquad (6.2)$$

With three natural constants c_{CP} (see equation 4.1), h_{CP} (see equation 4.2) and G_{CP} (equation 6.2) now being defined, the Martian had three equations that relate their respective values to their Metric counterparts:

C_{CP} : 1 (dimensionless) = c ($m.s^{-1}$) (6.3)

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h_{CP} : 1 P.C $= h$ (N.m.s) (6.4)
G_{CP} : 1 $C.P^{-1}$ $= G$ (Nm^2kg^{-2}) (6.5)

Thereby, the left sides of the equations express the natural constant in Crenel Physics units of measurement, whereas the right sides express these in Metric units of measurement. From these three equations one can extract P and C, and express these in Metric units as follows:

In equation (6.4) symbol 's' in the unit of measurement can be replaced by 'c m' because 1 time unit (here 'second') can be converted to 'c' distance units (here 'meter') . Equation (6.4) can then be written as:

1.P.C $= h$.c ($N.m^2$) (6.6)

Based on Einstein's $E=m.c^2$, 1 mass unit (here: 'kg') corresponds to c^2 energy units (here Joules) or c^2 (N.m). In equation (6.5) 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}) (6.7)

Dividing equation (6.6) by equation (6.7) gives:

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

Or:

$$1\,Package = \sqrt{\frac{h.c^5}{G}}\;\boldsymbol{Joule} = \text{4.90333830E+09 Joule} \quad (6.8)$$

Note, that if one substitutes the Crenel Physics values $C_{CP} = 1$, $h_{CP} = 1$ C.P, and $G_{CP} = C.P^{-1}$ in the above equation, the outcome is indeed 'Package', such that the equation is verified to be valid in Crenel Physics from a dimensional analyses point of view.

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

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$$1\,Package = \sqrt{\frac{h.c}{G}}\;\boldsymbol{kg} = \text{5.45569963E-08 kg} \qquad (6.9)$$

Note, that if one substitutes the Crenel Physics values $C_{CP} = 1$, $h_{CP} = 1$ C.P, and $G_{CP} = C.P^{-1}$ in the above equation, the outcome is indeed 'Package', such that the equation is verified to be valid in Crenel Physics from a dimensional analyses point of view.

Based on $\mathbb{E} = h.v$, equation (6.8) 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:

$$1\,Package = \sqrt{\frac{c^5}{h.G}}\;\boldsymbol{Hertz} = \text{7.40007065E+42 Hz} \qquad (6.10)$$

Note, that if one substitutes the Crenel Physics values $C_{CP} = 1$, $h_{CP} = 1$ C.P, and $G_{CP} = C.P^{-1}$ in the above equation, the outcome is indeed 'Crenel^{-1}', such that the equation is verified to be valid in Crenel Physics from a dimensional analyses point of view.

Multiplying equation (6.6) with equation (6.7) gives:

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

Or:

$$1\,Crenel = \sqrt{\frac{h.G}{c^3}}\;\boldsymbol{meter} = \text{4.05121075E-35 m} \qquad (6.11)$$

Note, that if one substitutes the Crenel Physics values $C_{CP} = 1$, $h_{CP} = 1$ C.P, and $G_{CP} = C.P^{-1}$ in the above equation, the outcome is indeed 'Crenel', such that the equation is verified to be valid in Crenel Physics from a dimensional analyses point of view.

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

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$$1\ Crenel = \sqrt{\frac{h.G}{c^5}}\quad \boldsymbol{seconds} = 1.35133845\text{E-43 s} \qquad (6.12)$$

Note, that if one substitutes the Crenel Physics values $C_{CP} = 1$, $h_{CP} = 1$ C.P, and $G_{CP} = C.P^{-1}$ in the above equation, the outcome is indeed 'Crenel', such that the equation is verified to be valid in Crenel Physics from a dimensional analyses point of view.

By substituting equation (6.8) –the conversion from Package towards 'energy' units of measurement - into equation (5.3) one finds the conversion factor from T_{CP} towards Kelvin:

$$1^0\ \ T_{CP} = \sqrt{\frac{h.c^5}{G.(k_B)^2}}\ \text{Kelvin} = 3.55147399\text{E+32 K} \qquad (6.13)$$

In above equation (6.13) one must use Boltzmann's constant k_B in the version, whereby it is expressed in J/K:
k_B=1.3806488 x 10^{-23}J/K.
This is because the Package conversion factor towards 'energy' was used.

Alternatively, this same result can be found by substituting equation (6.10) –the conversion from Package towards 'frequency- which results in:

$$1^0\ \ T_{CP} = \sqrt{\frac{c^5}{h.G.(k_B)^2}}\ \text{Kelvin} = 3.55147399\text{E+32 K} \qquad (6.13a)$$

In above equation (6.13a) one must then use Boltzmann's constant k_B in the version, whereby it is expressed in Hz/K:
k_B=2.0836618 x 10^{10}Hz/K. This alternate option results in the exact same result in Kelvin.

Finally, the Martian was interested in introducing a measure for 'Force', as used in equation (6.1). By substituting the conversion factor for 'Mass' (per equation (6.9)) and for 'Distance' per equation (6.11)) respectively into equation (6.1) he found:

$$1\ F_{CP} = G\ \times \frac{\sqrt{\frac{h.c}{G}} \times \sqrt{\frac{h.c}{G}}}{\left\{\sqrt{\frac{h.G}{c^3}}\right\}^2} = \frac{c^4}{G}\ Newton = 1.210339\text{E} + 44\ \text{N} \qquad (6.14)$$

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Professor Earth was somewhat surprised when evaluating the conversion factors. He noted that equations (6.8) through (6.14) show resemblance with the well-known 'Planck's natural units of measurement'. Albeit that the above conversion factors hold Planck's constant '*h*', whereas Planck's units of measurement –as found in literature- hold the 'reduced Planck constant 'h/2.π' (for which symbol '$\hbar$' is typically used). He was surprised by the relative easiness of achieving these results. It demonstrated that in setting up a lean system of units of measurement –based on Crenel and Package only- the Martian nevertheless delivered an unambiguous (that is: non-relativistic) set of measures for mass, energy, frequency, time, distance, temperature and force, consistent with Planck.

> Note: Max Planck proposed the currently named 'Planck units of measurement' in 1899, way before Einstein came up with his equation $E=m.c^2$. Einstein's equation has been used gratefully here. Therefore the original whereabouts of the 'Planck units of measurement' are much harder to understand.

But on top of that the Martian had introduced the dimension 'Information Temperature' as an additional Package dimension, whereby the Planck temperature plays a role as temperature yardstick.

The explanation for the difference between Planck units of measurement (as found in literature) and the here actually found conversion factors lies in the selected conversion rate between 'content' and 'whereabouts'. In Crenel Physics the Martian opted for a conversion rate that is 'frequency based', whereas –to get full consistency with Planck units of measurement- the *angular* frequency would have to be used instead, as a valid alternative. This explains why in Crenel Physics the equations (6.8 through (6.13) contain Planck's constant '*h*' rather than the reduced Planck constant '$\hbar$'.

Nevertheless, the above results obviously salute the well-known 'Planck' units of measurement, which indicated to Professor Earth that the Crenel Physics model is in line with main stream physics.

The Martian now reached the point where he could verify the relationship between macroscopic and microscopic values of Boltzmann's constant as listed in chapter 5 (and as can be found in e.g. Wikipedia):

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k_B	=	$1.3806488 \times 10^{-23}$	J/K
k_B	=	2.0836618×10^{10}	Hz/K
k_B	=	1.442695	bit
k_B	=	1	nat

The conversion from 'nat' to 'bit' was already identified as 1/ln(2). To find the conversion factor from k_B in 'nat' to the macroscopic value of k_B in J/K one must divide the conversion factor from Packages to Joules (equation 6.8) by the conversion factor from T_{CP} to Kelvin (equation 6.13):

$$k_B \equiv \frac{4.90333830\text{E}{+}09\ \text{Joule}}{3.55147399\text{E}{+}32\ \text{K}} \times 1\ '\mathit{nat}' \equiv 1.38064880\text{E-}23\ \text{J/K} \tag{6.15}$$

This result indeed and exactly matches the above listed value for k_B in J/K. Likewise, to find the macroscopic value from k_B in 'nat' to k_B in Hz/K one must divide the conversion factor from Packages to Hertz (equation 6.10) by the conversion factor from T_{CP} to Kelvin (equation 6.13):

$$k_B \equiv \frac{7.40007065\text{E}{+}42\ \text{Hz}}{3.55147399\text{E}{+}32\ \text{K}} \times 1\ '\mathit{nat}' \equiv 2.0836618\text{E}{+}10\ \text{Hz/K} \tag{6.16}$$

Again the result indeed and exactly matches the above listed value for k_B in Hz/K.

Due to the definition of 'Temperature' per equation (5.3) this relationship between microscopic and macroscopic values of Boltzmann's constant was of course foreseeable. However, to many physicists this unambiguous relationship between the microscopic world and the macroscopic world has snowed under. It was quite relevant that the Martian made the relationships transparent.

The Martian now documented the found conversion factors into his model as follows:

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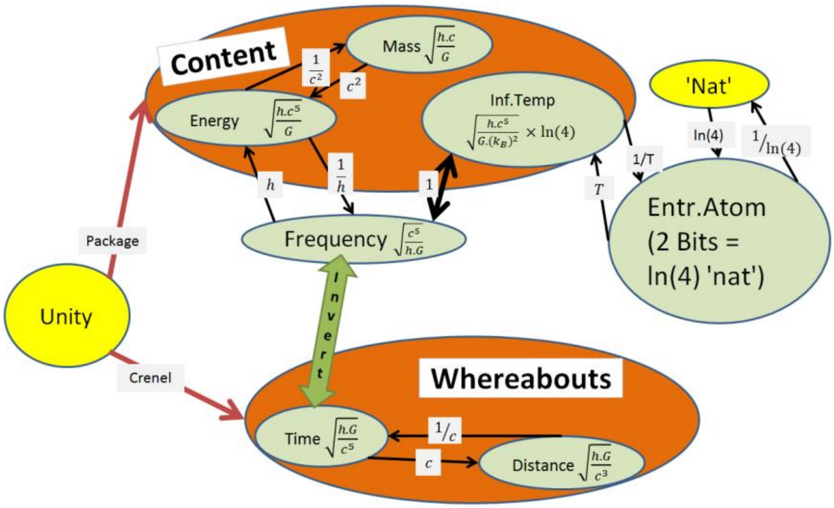

Fig. 6.1: Dimensions and their conversion factors.

Figure (6.1) delivers non-relativistic yardsticks for all shown dimensions, the reason being that it only contains universal natural constants *c, h, G,* k_B and mathematical procedures *inversion* and *natural logarithm* (here: ln(4)).

What the Martian also noted was that four universal natural constants are shown in the 'content' cluster, whereas only three dimensions of the Package were identified (so far). This reflects an over-dimensioning in the model in terms of the number of universal natural constants: that number is higher than –mathematically-needed. Mathematically it is sufficient to have only three (instead of four) universal natural constants. The Crenel Physics model per Figure (6.1) therefore demonstrates an over-dimensioning in terms of required universal natural constants.

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7. Eliminating the over-dimensioning.

As a first step, the Martian reviewed the role of natural constant '*c*'. This universal natural constant was found equal to 'unity', shaping the very basis of the Crenel physics model. Thus, '*c*' was unambiguously represented. At the same time, with '*c*' being equal to 'unity', there is no added value in showing '*c*' (or higher mathematical powers thereof) in the respective conversion factors. Thus, part of the over-dimensioning in the Crenel Physics model could be tackled. After eliminating 'c', figure (6.1) looked as follows:

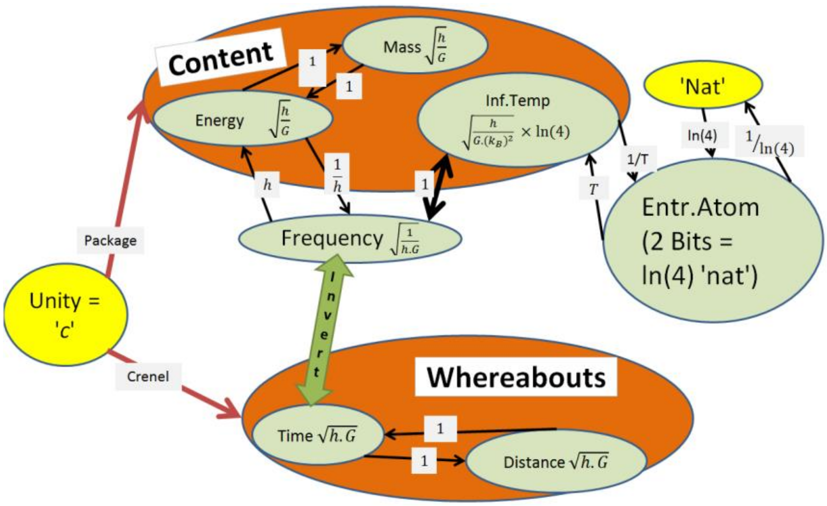

Figure 7.1: the Crenel Physics model, phase 1.

He browsed through this figure again. It shows 'unity'='c' as one of the two starting points. This 'unity'='c' contains two dimensions: Crenel and Package. These can respectively be represented by two orthogonal unit vectors (see equations (4.5) and (4.5a)).

The Crenel –in turn and so far- also contains two dimensions, represented as orthogonal unit vectors: 'time' and 'distance'. Both use the same yardstick: the Crenel. As the figure shows, the length of each unit vector (1 Crenel) can also be expressed in universal natural units, in both cases this length is equal to: $\sqrt{h.G}$.

The Package –in turn and so far- contains three orthogonal unit

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vectors: 'Energy', 'Mass' and 'Information Temperature'. All three use the same yardstick: the 'Package'. Or: each of these unit vectors has a length of 1 Package. Again, that same length can also be expressed in universal natural units of measurement, as shown in the figure. The length of both 'Mass' and 'Energy' was found to equal:

$$\sqrt{\frac{h}{G}}$$

The length of the 'Information Temperature' vector was –besides equal to 1 Package- found to equal:

$$\sqrt{\frac{h}{G.(k_B)^2}} \times \ln(4)$$

The Martian now reviewed figure (7.1) for options to further streamline. He wondered about the added value of those cases where the unit vector length between two shown dimensions –when expressed in universal natural units- match. Such is the case between 'Mass' and 'Energy' in the 'Content' cluster, and 'Time' and 'Distance' in the 'Whereabouts' cluster. To understand the implications of such a match, he re-considered the conceptual difference between a 'unit of measurement' (such as the 'meter') and a 'dimension'. As already found, with one unit of measurement (e.g. the 'meter') one can span multi-dimensions (e.g. m, m^2, m^3, m^4, m^5, etc.). Between these dimensions there is however no difference in their physical basis. Or: these various dimensions share the same physical concept because along each coordinate (X,Y,Z, etc.) one can use the same sensor (here: a yardstick) to measure a coordinate. In the particular case of 'Energy/Mass' one would need to develop a sensor that responds to $\sqrt{\frac{h}{G}}$. Once available, that sensor can be used to measure the contained 'Mass' as well as the contained 'Energy' of an object. Likewise, if one would develop a sensor that responds to $\sqrt{h.G}$, that sensor can be used to measure both 'Time' and 'Distance' alike.

Based on this shared 'sensor' criterion, the Martian decided to enhance his definitions in the Crenel Physics model. He decided to differentiate between 'dimensions' and 'coordinates' (besides his definition of 'units of measurement'). To make the point easier to understand, he used Metric Physics as his temporary playing ground. Here, according to his new definitions, examples of 'units of measurement' are: 'm', 's', 'kg', 'Hz'. Examples of 'dimensions' are

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combinations thereof, e.g. 'm/s', 'm/s^2', 'kg/m'. So far there is nothing new yet. But now he decided to add 'coordinates' to his definitions as being 'higher orders' of either 'units of measurement' or 'dimensions' alike. That definition makes the m^2, m^3, m^4, m^5, etc. all 'coordinates' of the *unit of measurement* 'meter'. The discriminating reason for being 'coordinates' of the 'meter' is that one needs one single sensor (here: a yardstick that measures meters) to serve any distance measurement within this entire arena.

Likewise, the higher powers of e.g. 'velocity' in 'm/s' (thus: $(m/s)^2$, $(m/s)^3$, $(m/s)^4$, $(m/s)^5$, etc.) are all 'coordinates' of the *dimension* 'm/s'. The discriminating reason for being 'coordinates' of the 'm/s' is again that one needs a single sensor (here: a velocity meter that measures in 'm/s') to serve any velocity measurement within this arena.

He discussed this sensor criterion with professor Earth. "With the definition of 'coordinates' being higher powers of 'dimensions', I see no added value in showing 'dimensions' more than once in my Figure (7.1), as I obviously did. Coordinates are nothing but trivial enhancements to a 'unit of measurement' or to a 'Dimension'. I say 'trivial' because such enhancements can be served by the same sensor, and therefore 'coordinates' do not add *physical* insight. Such enhancements can be entirely dealt with through mathematical rules."

Professor Earth was willing to accept the discriminating role that was assigned to sensors. In Metric Physics he used a watch as a sensor for measuring 'time' (responding to 's'), and a yardstick for measuring 'distance' (responding to 'm'). If he now would need to construct a sensor for measuring 'velocity', he indeed would have to construct a third sensor (responding to 'm/s'). Although that third sensor would be based on the two sensors he already had for 'time' and for 'distance', it would nevertheless be an entirely new sensor type with a different purpose: it measures 'm/s' in the velocity arena. At the same time, despite being constructed of an 'm' component and an 's' component, that sensor would in turn not be usable to measure e.g. acceleration (m/s^2) or flow (m^3/s) (both are examples of other potential combinations of the 'meter' and the 'second'). However –by using only mathematical rules and no additional physics at all- this new velocity sensor can be used e.g. in the orthogonal $(m/s)^2$ space with coordinates X and Y, and also e.g. in the orthogonal $(m/s)^3$ space with coordinates X, Y and Z, etc.. Therefore, using the capability of a sensor as a unique and discriminating factor between the numerous potential coordinates –as defined by the

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Martian- is a valid and pragmatic approach. Consequently, the merging of dimensions that share their sensor type –as proposed by the Martian- is an unambiguous operation that hides 'trivial' mathematical enhancements, but it will not hide any physics. Besides that, Figure (7.1) doesn't show the full capabilities of these mathematical enhancements anyway. Professor Earth concluded that the Martian in his Crenel Physics model simply unmasked Energy/Mass as being two orthogonal coordinates of one single dimension of the Package, and likewise unmasked Time/Distance as being two orthogonal coordinates of one single dimension of the Crenel. Just like 'length' and 'width' of a rectangle are physically equal properties. Thus he concurred to the Martian's effort to merge equal 'coordinates'. This lead to the following:

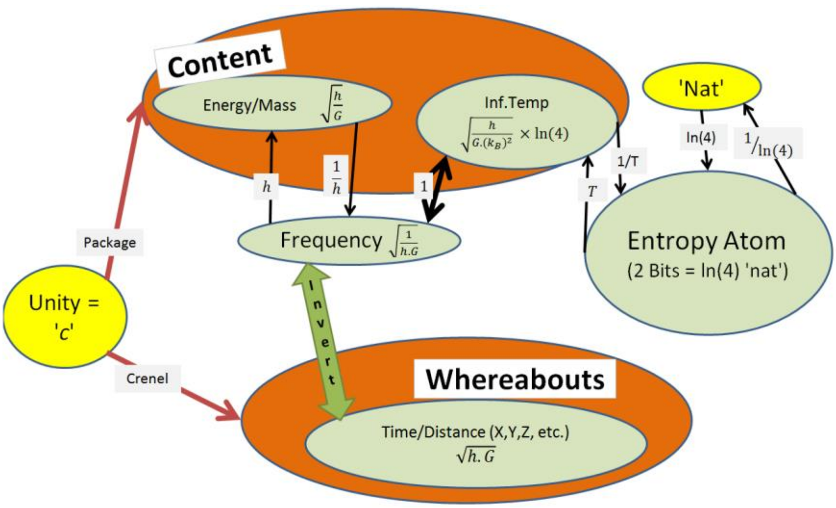

Figure 7.2: Crenel Physics model, phase 2.

'Energy/Mass' and 'Information Temperature' are orthogonal unit vectors. The Martian now named these vectors $\overrightarrow{EM}$ and $\overrightarrow{IT}$ respectively. Still, both vectors have a length of one Package. As shown in figure (7.2) the length of vector $\overrightarrow{EM}$ (represented as $\|\overrightarrow{EM}\|$) can also be found through natural constants via the earlier found conversion factor:

$$\|\overrightarrow{EM}\| = \sqrt{\frac{h}{G}} \quad (7.1)$$

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The length of the 'Information Temperature' vector (represented as $\|\overrightarrow{IT}\|$) can also –as earlier found- be expressed through natural constants:

$$\|\overrightarrow{IT}\| = \sqrt{\frac{h}{G.(k_B)^2}} \times ln(4) \tag{7.2}$$

Using that same notation, the unit vector 'Time/Distance' (which has a length of 1 Crenel) can be expressed in natural constants as follows:

$$\|\overrightarrow{TD}\| = \sqrt{h.G} \tag{7.3}$$

When the above vector notations are substituted into Figure (7.2), and after some layout modifications, this figure can be redrawn as follows:

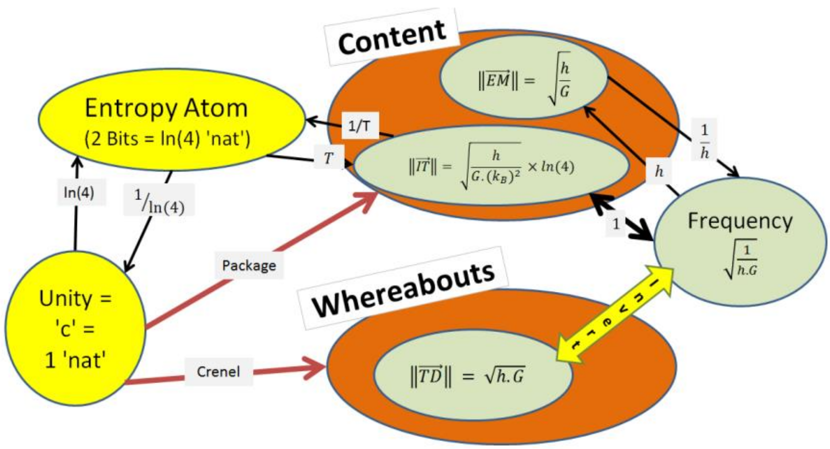

Fig. 7.3: Crenel Physics model, phase 3.

In the model, '*c*', 'unity' and 1 'nat' are mathematical as well as physical equivalents. Therefore these three identical entities are now shown in one node of the model.

Professor Earth had monitored the Martian during his efforts of streamlining the model. Together they decided to re-capture in words what the model –in phase 3- shows:

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Starting point is 'unity', which is a property that can be universally shared between cultures because 'unity' is a mathematical property. Due to the normalization procedure that was followed in Crenel Physics, 'unity' also represents the velocity of light in vacuum. Furthermore, 'unity' is the mathematical equivalent of 1 'nat', which in turn represents Boltzmann's constant, both in Metric Physics as well as in Crenel Physics.

'Unity' is composed of two 'dimensions':

1. The 'whereabouts', where the 'Crenel' is the yardstick.
   In turn, this 'whereabouts' contains a dimension vector 'Time/Distance' (see equation 7.3) of which a multi-dimensional time-space system of coordinates can be constructed. By expressing the yardsticks in terms of natural constants, the 'time' yardstick is associated with the Crenel Physics counterpart of 'Planck time', and the 'distance' yardstick is associated with the Crenel Physics counterpart of 'Planck distance'. Due to the normalization of the speed of light (towards 'unity'), in the Crenel Physics model the physical difference between 'time' coordinates and 'distance coordinates' thereby vanishes.

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2. The 'content', where the Package is the yardstick.
   In turn, this 'content' contains two dimension vectors: $\overrightarrow{EM}$ and $\overrightarrow{IT}$.
   The $\overrightarrow{EM}$ vector (see Equation (7.1)) can be used to span an 'energy' dimension, for which the yardstick –when expressed in natural units of measurement- corresponds to the Crenel Physics counterpart of 'Planck energy'.
   The $\overrightarrow{EM}$ vector can be also be used to span a 'mass' dimension, for which the yardstick –when expressed in natural units of measurement- corresponds to the Crenel Physics counterpart of 'Planck mass'.
   And finally there is the 'Information Temperature' vector, see Equation (7.2). It integrates Boltzmann's theory into the Crenel Physics model. Via this theory one can construct an 'Entropy Atom': the smallest entity that one can observe as an isolated object. It is constructed of 2 bits (or: ln(4) 'nat'). An 'Entropy atom' at a temperature equal to the 'Planck temperature' (that is: the Crenel Physics version thereof) also contains 1 Package.

A dimensional check shows that equations (7.1), (7.2) indeed produce a result in Packages (substitute P.C for '*h*', and substitute C/P for '*G*'). Likewise, Equation (7.3) indeed produces a result in Crenels.

The Martian now reviewed the two dimensions $\overrightarrow{EM}$ and $\overrightarrow{IT}$ in the 'contents' cluster. The two vectors are orthogonal unit vectors, that thus can span e.g. a two dimensional space (just like e.g. ten instances of the $\overrightarrow{EM}$ vector can span a 10-dimensional space). It reminded him of the X and Y coordinates in a Cartesian system of coordinates, spanning a plane. X and Y are both expressed in meters, and surface is expressed in square meters. To ensure that the conservation law is obeyed (or: that the surface of a rectangle is always length x width, regardless its orientation) the system of coordinates must be orthogonal. He now applied this reasoning to the two unit vectors at hand. Both have a length of 1 Package. Therefore, the surface of a square with side lengths of 1 Package equals 1 Package^2. The multiplication of vectors as applied here is –mathematically- referred to as 'Geometric Multiplication', which can be thought of as a combination of cross and dot multiplication of vectors. That exact same result must be produced when the vector-

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lengths are expressed in natural units of measurement. This requirement is expressed as follows:

$$\sqrt{\frac{h}{G}} \times \sqrt{\frac{h}{G.(k_B)^2}} \times ln(4) \equiv 1\ (Package^2) \tag{7.4}$$

Or:

$$k_B \equiv \frac{h.ln(4)}{G} * (Package^{-2}) \tag{7.5}$$

Equation (7.5) shows a relationship between universal natural constants. This, as such, is a remarkable finding in that universal natural constants are supposedly completely independent relative to each other. Equation (7.5) does however underline that the single purpose of universal natural constants is, to serve as –universal- conversion factor between dimensions (or: units of measurement). Figure (7.3) shows only three dimensional vectors: $\overrightarrow{EM}$, $\overrightarrow{IT}$ and $\overrightarrow{TD}$. Therefore, mathematically it is sufficient to have only two universal constants addressing the mutual conversions between these in an unambiguous manner.

Equation (7.5) can be substituted into Equation (7.2), which then results in:

$$\left\|\overrightarrow{IT}\right\| = \sqrt{\frac{h}{G.\left\{\frac{h.\,ln(4)}{G} * (Package^{-2})\right\}^2}} \times ln(4)$$

$$\left\|\overrightarrow{IT}\right\| = \sqrt{\frac{G}{h}} \times (Package^2) \tag{7.6}$$

Based on the equation (7.6), Boltzmann's constant k_B can be eliminated from the model, which thus was updated as follows:

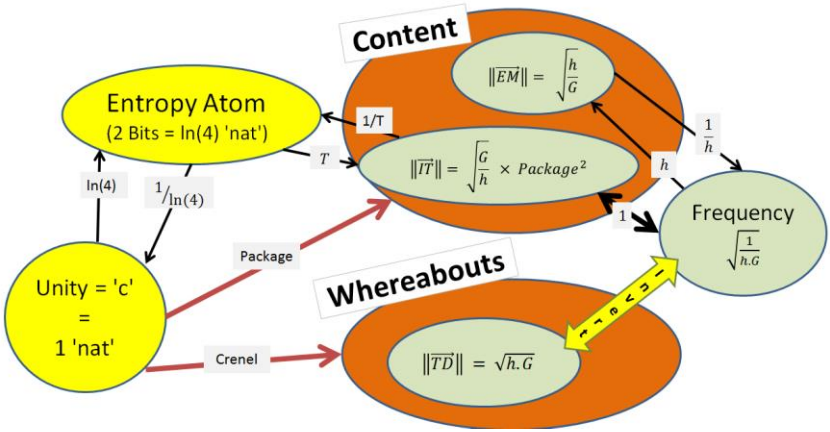

Fig. 7.4: Crenel Physics model, based on Equation (7.5).

It was only now that the Martian was satisfied. The Crenel Physics model now shows three dimensions, each based on 'unity' (which is the equivalent to the velocity of light in vacuum). The mutual conversion between these three dimensions requires two (and no more than two) universal natural constants: here h and G. Thus, the model is not over-dimensioned anymore. And for that matter: h or G can be replaced by Boltzmann's constant k_B via Equation (7.5). In turn, the three found dimensions and any power or combination thereof can be used to construct the universe.

The intriguing finding here however is expressed through Equation (7.5): where Metric Physics produces three independent universal natural constants G, h and k_B, the Crenel Physics model reveals – through integrating Boltzmann's theory- that one of these (any one) can be eliminated.

This was the moment to evaluate if and how this key finding, represented through equation (7.5), is compatible with Metric Physics.

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8. Planck units reviewed.

To professor Earth the most intriguing finding so far is represented by equation (7.5):

$$k_B \equiv \frac{h.ln(4)}{G} \tag{8.1a}$$

This equation can also be written as:

$$G \equiv \frac{h.ln(4)}{k_B} \tag{8.1b}$$

This relationship between universal natural constants –as shown- is a novelty in physics because universal natural constants are supposedly independent relative to each other. This was good reason to review this result for its consistency.

Within the Crenel Physics model, from a dimensional point of view equation (8.1b) matches: one can substitute *h=P.C* and *G=C/P*, whereby k_B then equals the dimensionless ln(4) = 2 bits. This match is logical, because within the model 'content' -along the 'Information Temperature' dimension- is measured in chunks of 2 bits (that is: of 'entropy atoms') multiplied by their 'temperature'.

It now was time to verify that equation (8.1b) is also valid in the Metric Physics system of units of measurement. This verification involves two steps: first the analyses in terms of universal natural constants (that are expressed differently between Metric Physics and Crenel Physics) and second the numerical verification.

In Metric Physics the relevant natural constants are expressed as follows:

$G = 6.67384 * 10^{-11}$ N.m^2.kg^{-2} (8.2a)
$h = 6.62606957 * 10^{-34}$ J.s (8.2b)
$k_B = 1.3806488 * 10^{-23}$ J/K (8.2c)

To find the numerical values of the above three natural constants, one must replace the shown Metric units by their Crenel Physics conversion factors using equations (6.8) through (6.14). Or:

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G = (Planck Force)x(Planck Distance)^{2}x(Planck Mass)$^{-2}$ (8.3a)
h = (Planck Energy)x(Planck Time) (8.3b)
k_B= (Planck Energy)/(Planck Temperature) (8.3c)

If one substitutes the conversion factors as given in the aforementioned equations, the numerical values as shown by (8.2a), (8.2b) and (8.2c) are indeed and exactly reproduced. E.g. if one multiplies 'Planck Energy' with 'Planck Time' (see Equation (8.3b) the outcome –exactly- matches the value shown in (8.2b). As already mentioned: this is the inherent outcome of how these conversion factors were calculated in Crenel Physics (name it: 'reverse engineering'). The surprise here is that these conversion factors resembled the universal Planck units of measurement via the followed 'low threshold' procedure. In Metric Physics the whereabouts of Planck units of measurement are harder to understand (because these were proposed in 1899, prior to Einstein's E=m.c^2).

The Martian and Professor Earth agreed that a likewise verification of equation (7.5) –when applied in Metric Physics units of measurement- should also be done as a verification that the findings so far are consistent. They decided to do this verification by usage of Equation (8.1b), because this equation reflects that the gravitational constant '*G*' –hard to measure in practice- can be calculated from other universal natural constants.

Here, the left side of Equation (8.1b) (gravitational constant 'G') is expressed in its Crenel Physics version, that is: in Crenel Physics units of measurement. The verification should now confirm that when converted into Metric units of measurement, it still equals 'G' (but now expressed in Metric units of measurement). The Metric unit of measurement of 'G' is: N.m^2.kg^{-2}, see Equation (8.2a). The conversion factor to convert from Crenel Physics units of measurement towards this Metric Physics unit of measurement is given by equation (8.3a). The conversion factors are found in chapter 6 through equations (6.14), (6.11) and (6.9) respectively. These can now be substituted into (8.3a). This gives:

$$\frac{c^4}{G} \times \left\{\sqrt{\frac{h.G}{c^3}}\right\}^2 \times \left\{\sqrt{\frac{h.c}{G}}\right\}^{-2} = \frac{c^4}{G} \times \frac{h.G}{c^3} \times \frac{G}{h.c} = G \qquad (8.4)$$

Therefore, after conversion towards Metric units, the left side of equation (8.1b) indeed results –as expected- in its Metric Physics counterpart '*G*'.

> Note that in Equation (8.4) the velocity of light 'c' disappears. Therefore, the normalization of 'c' towards 'unity' is not relevant to the outcome of Equation (8.4). Or: even without such normalization (such as is the case in Metric units of measurement) the above dimensional check will hold.

Likewise, the right side of equation (8.1b) can be verified: the dimension of h/k_B in Crenel Physics units of measurement should therefore be found equal to the dimension of h/k_B in Metric Physics units of measurement. To verify this, Equations (8.3b) and (8.3c) can be used. According to these, the ratio 'h/k_B' in Crenel Physics units of measurement then equals 'Planck Time' x 'Planck Temperature', for which the conversion factors are given by Equations (6.12) and (6.13) respectively:

$$\sqrt{\frac{h.G}{c^5}} \times \sqrt{\frac{c^5}{h.G.(k_B)^2}} = \frac{h}{k_B} \qquad (8.5)$$

Thus the Martian concluded that equation (8.1b) -from a dimensional viewpoint- is also valid in Metric Physics (and should be valid in any other consistent system of units of measurement).

The Martian decided to take a helicopter view on 'systems of units of measurement', regardless Metric or otherwise.

From his perspective the set of Planck units is 'de facto' nothing but some consistent set of independent dimensions, geared to human sensors. Thereby, 'Planck Mass' and Planck Energy' belong in the 'content' arena, whereas 'Planck Time' and 'Planck Distance' belong in the 'whereabouts' arena. Each Planck unit is expressed in natural constants (see equations (6.8) through (6.14)), and therefore meets the requirement that mutual conversions are –in turn- based on natural constants only. Thereby and therefore the universal conservation principle is safeguarded. However, as seen from his helicopter, the Martian also concluded that one might as well bite the bullet and set up a simpler frame of dimensions. The natural constants *themselves* therein shape the coordinates. It would then be up to the Martians to decide whether they need like Earth people –for example- a property named 'Mass', and that this property is expressed in $\sqrt{\frac{h.c}{G}}$ (per equation (6.9)). Maybe the Martians were blessed with some sense organ that allows them to sense 'clucks' (so

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to speak), which –strangely enough- are expressed in $\sqrt{\frac{h^2.c^3}{G^5}}$ or some other combination of natural constants. Conceptually those 'clucks' would then shape a dimension that is as valid as the 'Content' dimension or the 'Whereabouts' dimension. In other words: there is no conceptual argument for denying or allowing dimensions, as long as these are based on universal natural constants (perhaps yet unidentified) and mathematical procedures. However, based on the Crenel Physics model –so far- different cultures will share at least two mathematical anchor points between them: 'unity' and the 'bit'. It thereby fits the human perception of the universe, that the two independent (orthogonal) dimensions 'content' and 'whereabouts' are based on these as next first level in constructing *their* dimensional model. As next higher level humans initially used their sense organs, resulting in base properties that are associated with the Planck units of measurement. Down the line this gave humans the laws of Newton, Keppler, etc.. But so far the Martian had found no conceptual argument to deny completely different models of that same universe. He found only a very limited set of rules here, all –at their bottom line- based on the conservation principle.

The added value of the Crenel Physics model is, that a new and yet unidentified entry into the 'contents' arena was found via Boltzmann. This new entry did lead to equation (7.5). The postulation thereby was that the sensible universe is constructed of 'entropy atoms' in their bi-bit version.

Having put things within this broader perspective, it was time to return to his Crenel Physics model, and to verify the above postulation in Metric Physics by entering the numerical values for the natural constants per (8.2b) and (8.2c) into Equation (8.1b):

$G \equiv \frac{h.ln(4)}{k_B}$ then results in:

$$G = \frac{6.62606957 \times 10^{-34}}{1.3806488 \times 10^{-23}} \times 1.386294 = 6.653163 \times 10^{-11} \qquad (8.6)$$

This is 99.69 % of the actually measured value of 'G' as found in literature, and given by (8.2a): 6.67384 * 10^{-11}.

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9. Discussion.

In the Crenel Physics model the explanation for the undershooting of 'G' by 0.31% can be found in that the Crenel Physics model describes the gravitational force between two entropy atoms, rather than between two macro objects (that can be seen as ensembles of entropy atoms).

Entropy atoms form the basis of a whole family of elementary particles. Within the current Crenel Physics state of development, one thereby cannot differentiate between a bi-bit and a tri-bit particle: in both cases one exchanges some 'temperature' dependent bit-rate with a bandwidth of 1 bit only. Perhaps, bi-bits can be associated with bosons (such as photons), and tri-bits with fermions.

The temperature of an entropy atom is not to be confused with the macroscopic temperature of an ensemble. One can e.g. assign a temperature value to an isolated photon, e.g. coming from a monochromatic laser beam. However, that beam may cross a room where the air temperature (that is: the ensemble temperature of the gas molecules) is considerably different. And crossing the room may lead to some heat exchange, but most photons within the laser beam will cross the room without interaction and without loss of contained energy/Packages.

At this point the Crenel Physics model leaves open a variety of potential explanations for the found difference between a value of '*G*' between entropy atoms, and a –higher- value for '*G*' in case of ensembles thereof.

As already indicated, the most logical explanation would be as follows:

> The degrees of freedom of entropy atoms within an ensemble add to the total entropy, and –combined with an ensemble macroscopic temperature- this adds to the Package containment of the ensemble (= a macroscopic body). The consequence thereof would be that the gravitational pull between two macroscopic bodies is found stronger, relative to the summation of gravitational pulls as found between the individual entropy atoms. Such higher gravitational pull would then –wrongfully- be effectuated by a presumed value

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of ‘G’ that is accordingly higher.

Or: the concept that a macroscopic body contains energy per Einstein’s equation $E=m.c^2$ is not complete: the body also contains thermal energy associated with its macroscopic entropy multiplied with its macroscopic temperature. In other words: if one heats up a body, one not just increases its energy containment. In such case one increases its Package containment and thereby it’s gravitational pull.