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Boltzmann Gravity

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1. The Crenel and the Package.

Einstein’s equation $\mathbb{E} = \text{m}.c^2$ shows that energy can be converted into mass, and vice versa. The conversion factor ’c^2’ is a ‘universal natural constant’. Therefore the conversion procedure is ‘non-relativistic’.

Likewise, Planck’s equation $\mathbb{E} = h.v$ shows that energy can be converted into frequency. The conversion factor thereby is Planck’s universal natural constant ‘h’. Again, the conversion procedure is non-relativistic.

Therefore, the units of measurement for mass, energy and frequency are unambiguously related to each other. Should Martians (so to speak) decide to set up their own system of units of measurement, and thereby define measures for ‘mass’ and ‘energy’, they thereby would inherently have fixed the value and unit of measurement for ‘c^2’ (and thereby the velocity of light ‘c’), perhaps without knowing it yet.

Given the above unambiguous relationships between units of measurement, the conclusion is that nature does not need all of these. We will explore a leaner alternative, which –to avoid confusion- we will name ‘Crenel Physics’.

Firstly, we introduce a new unit of measurement: the ‘Crenel’ (symbol ‘C’). We will use it as a measure for both distance AND time. Thus velocity is expressed in Crenel/Crenel, which makes its unit of measurement dimensionless. By using the Crenel both for distance as well as time measurement, the light speed ‘c’ inherently is equal to (dimensionless) 1. Thus in Crenel Physics we define the natural constant ‘velocity of light’ as follows:

$$c_{CP} = 1 \tag{1}$$

The subscript ‘CP’ in equation (1) expresses that this is the Crenel Physics version of light velocity ‘c’.

Secondly, we introduce the ‘Package’ (symbol ‘P’) as a measure for ‘content’: both mass and energy containment of an object will be expressed in Packages. Because the velocity of light was found to equal dimensionless 1, the conversion procedure between mass and

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energy (Einstein's equation) is 'de facto' embedded in Crenel Physics: mass=energy.

> One must differentiate between 'units of measurement' and 'dimensions'. In Metric Physics, the meter is a 'unit of measurement'. This unit of measurement can be used to e.g. span a spatial 3-dimensional space with dimensions X, Y and Z. Each of these dimensions thereby is expressed in the unit of measurement 'meter'. In general: any 'unit of measurement' can lie at the basis of numerous 'dimensions'. Relative to Metric Physics, the Crenel Physics model positions its units of measurement 'Crenel' and 'Package' one level deeper. Thus, the 'meter' and the 'second' are not units of measurement, but instead these are dimensions of the Crenel. And likewise, 'mass', 'energy' and 'frequency' are dimensions of the Package.

Finally, let's review Planck's $\mathbb{E} = h.v$. In Crenel Physics, energy $\mathbb{E}$ is expressed in Packages, and frequency v is expressed in Crenels^{-1}. Thus –perhaps without realizing it- we inherently specified the Crenel Physics version of Planck's constant:

$$h_{CP} = 1\ C.P \tag{2}$$

We now enhance the Crenel Physics model by exploring Newton's equation: $F = m.a$. In observing one single object, different observers are likely to find different values for the '*F*', '*m*' and 'a', pending their circumstances relative to the object. But at any instantaneous moment in time each of these observers would find that the relationship $F = m.a$ holds. Therefore, this Newtonian relationship is non-relativistic.

With mass being expressed in Packages ('P'), and acceleration being expressed in $\text{Crenel}/\text{Crenel}^2 = \text{Crenel}^{-1}$('$C^{-1}$'), the Crenel Physics unit of measurement for force is P/C.

Likewise, the equation for gravitational force between two masses $F = G.m_1.m_2/d^2$ must apply to any observer and any system of units of measurement, including ours. We therefore can substitute the Crenel Physics units of measurement for F, m_1, m_2 and d^2 into this equation. This results in the value for the Crenel Physics version of the gravitational constant G_{CP}:

$$G_{CP} = 1\ \frac{C}{P} \qquad (3)$$

With three natural constants c_{CP}, h_{CP} and G_{CP} defined, we thereby have three equations that relate their respective values to their Metric counterparts:

1 (dimensionless)	= c ($m.s^{-1}$)	(4)
1 P.C	= h (N.m.s)	(5)
1 $C.P^{-1}$	= G (Nm^2kg^{-2})	(6)

Thereby, the left sides of the equations must express the natural constant in Crenel Physics units of measurement, whereas the right sides must 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 (5) the symbol 's' in the unit of measurement can be replaced by 'c m' because in Metric Physics 1 second corresponds to 'c' meters. Equation (5) can then be written as:

1.P.C	= h.c ($N.m^2$)	(7)

Based on Einstein's $E=m.c^2$, 1 kg corresponds to c^2 Joules or c^2 (N.m). In equation (6) 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})	(8)

Dividing equation (7) by equation (8) gives:

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

Or:

$$1\ Package = \sqrt{\frac{h.c^5}{G}}\ \boldsymbol{Joule} = 4.90333830\text{E+09 Joule} \qquad (9)$$

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

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$$1\,Package = \sqrt{\frac{h.c}{G}}\ \boldsymbol{kg} = \text{5.45569963E-08 kg} \qquad (10)$$

Based on $\mathbb{E} = h.v$, equation (9) 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:

$$1\,Package = \sqrt{\frac{c^5}{h.G}}\ \boldsymbol{Hertz} = \text{7.40007065E+42 Hz} \qquad (11)$$

Multiplying equation (7) with equation (8) gives:

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

Or:

$$1\,Crenel = \sqrt{\frac{h.G}{c^3}}\ \boldsymbol{meter} = \text{4.05121075E-35 m} \qquad (12)$$

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

$$1\,Crenel = \sqrt{\frac{h.G}{c^5}}\ \boldsymbol{seconds} = \text{1.35133845E-43 s} \qquad (13)$$

Equations (9) through (14) show resemblance with the well-known 'Planck's natural units of measurement'. Albeit that the above equations 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 used). The above conversion results demonstrate that in setting up a leaner system of units of measurement –based on Crenel and Package only- we nevertheless delivered an unambiguous (that is: non-relativistic) set of measures

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for mass, energy, frequency, time and distance.

Above results thereby salute the well-known ‘Planck’ units of measurement.

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2. Boltzmann

Boltzmann's equation $S = k_B.\ln(w)$ specifies the entropy 'S' of a body. Entropy is a measure for a body's complexity. Parameter 'w' equals the number of states in which a body can reside. 'k_B' is a universal natural constant, rightfully named 'Boltzmann's constant'.

> One can apply this equation 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 'an object' that can reside in two states. A row of 'n' coins can reside in 2^n states. Boltzmann's equation then becomes: $S = k_B.n.\ln(2)$. This shows that entropy '*S*' grows proportionally with the number of coins '*n*'. Therefore 'entropy' is proportional to 'content', and thereby with the Package. This association will be further explored here.

In Metric Physics entropy is expressed in many units of measurement, from macroscopic (such as J/K and Hz/K) to microscopic (such as 'bit' and 'nat'). Per unit of measurement there is an associated value for Boltzmann's constant k_B. The –to Crenel Physics-most relevant values (as found 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

In all cases the same underlying physical fact is addressed. Consequently there is an unambiguous relationship between all versions of k_B. Let's explore this.

When we applied Boltzmann's equation to a row of coins, recognizing that each coin has two states, we ended 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. We thereby used 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, we can express the entropy in 'bit'. In that case our equation simplifies to $S= k_B.n$, whereby k_B is to be expressed in 'bit'. As mentioned, all ways of expressing the quantity of entropy of a

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body must address the same physical fact. This explains why k_B in 'nat' can be converted to k_B in 'bit' by applying the conversion factor 1/ln(2). This conversion factor indeed –as expected- delivers the above listed value for k_B in bit: k_B = 1.442695041 bit.

The 'nat' and the 'bit' are mathematical properties. Therefore they are shared between Metric Physics, Crenel Physics and any other system of units of measurement.

To explore the relationship between the above microscopic scales ('nat' and 'bit') at the one side, and the macroscopic scales ('J/K' and 'Hz/K') at the other, we first need to introduce a unit of measurement for temperature in Crenel Physics (T_{CP}). The common Metric Physics approach to define one degree of temperature is as follows:

$$1^0\ T = \frac{Unit\ of\ measurement\ for\ Energy}{k_B} \qquad (14)$$

In Crenel Physics, the Package is the unit of measurement for energy. Thus, in Crenel Physics equation (14) translates to:

$$1^0\ T_{CP} = \frac{Package}{k_B} \qquad (15)$$

By substituting equation (9) –the conversion from Package towards 'energy' units of measurement - into equation (15) we find the conversion factor from T_{CP} towards Kelvin:

$$1^0\ \ T_{CP} = \sqrt{\frac{h.c^5}{G.(k_B)^2}}\ \text{Kelvin} = 3.55147399\text{E+32 K} \qquad (16)$$

Note: the above conversion factor (as all the earlier found conversion factors) is equal to the 'Planck temperature', apart from Plank's constant '*h*' being used instead of the reduced Planck constant '$\hbar$'.

To now convert k_B from 'nat' into 'Hz/K' one needs to divide the Crenel Physics Conversion factor from Package towards Hz per equation (11) (= 7.40007065 x 10^{42} Hz) by the conversion factor from T_{CP} towards Kelvin per equation (16) (= 3.55147399 x 10^{32} Kelvin). This division gives a value 2.0836618 x 10^{10}, which indeed

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and exactly matches the above listed macroscopic value for k_B in Hz/K.

Finally, k_B in J/K can be found by multiplying the Hz/K value by 'h', which conversion is based on Planck's equation: $\mathbb{E} = h.\upsilon$.

The Crenel Physics model thus demonstrates the unambiguous connection between microscopic entropy and macroscopic entropy. Key thereby is that the Crenel Physics temperature scale is based on the 'nat', which is a mathematical property. Mathematical properties can be shared between all systems of units of measurement, just like the mathematical constants 'π' and 'e'.

Because the 'nat' and the 'bit' are non-relativistic yardsticks for entropy, any other unit of measurement for entropy, regardless whereabouts, also must be non-relativistic. Thus, where both Joule and Kelvin are properties that are relative to the observer, 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 a measure for 'complexity'. Consequently, the heat capacity of a body is a non-relativistic property than must be found equal between observers.

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3. The 'entropy atom'

In Metric Physics, gravity is described as the attracting force between two masses: $F = G.m_1.m_2/d^2$.

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

Photons bend their path in gravitational fields. Therefore their 'mass' appearance truly exists: it is proportional to their energy containment and/or frequency appearance. At bottom line it is not relevant which of the aforementioned photon's properties we decide to measure: one can convert the result per Einstein or Planck and conclude that all appearances are equally and simultaneously valid, and unambiguously related to each other via universal natural constants. This answers 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 we decide to measure).

This raises a second fundamental question: what minimum mechanism do we require in order to observe an object?

To answer it, one must consider that it we only can observe an object if we receive information from it. Per conservation principle it would be impossible for the observed object to send information, unless such sending is compensated. If we assume the object isolated and self-sustaining, this compensation requires a change of some internal parameter(s). The search for the smallest possible object that could meet this demand should therefore focus on an object's minimum required complexity, rather than on e.g. a minimum required Package containment (expressed as mass, energy, or frequency). 'Complexity', 'entropy', and 'heat capacity' of a body are synonymous physical concepts because all can be expressed in the same unit of measurement (e.g. in Bit or in J/K). Per Boltzmann's equation the entropy of a single state object equals 0, because in such case 'w' = 1 and ln(w)=ln(1)=0. Therefore we must scale up. Let's explore the next higher option: the simplest thinkable –non zero- object must be able to reside in at least two

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different states that can be characterized by a '1' and a '0'. Although objects with such a low complexity might exist, one would nevertheless not be able to detect these: in being an isolated object the conservation principle would prohibit it to change status. Or: none of its internal parameters (there is only one here) could change to compensate. Therefore, a minimum detectable object must represent an entropy/complexity/heat capacity of at least two bits. Thus, when one bit 'flips', the other must 'flop' to compensate. Note that there is no requirement that such compensation must take place instantaneous: e.g. in case the object spans some space one must assume that there is an internal retention mechanism associated with the maximum communication velocity between the two 'bits'.

> *We will name the minimum detectable objects 'entropy-atoms', and their entropy equals 2 bits, which is equal to 2.ln(2) or ln(4) 'nat'.*

With the smallest possible detectable object now being defined in terms of entropy/complexity/heat capacity, let's evaluate the following:

> *Detectable objects (and thereby the entire detectable universe) are constructed of minimum detectable objects, that is: of entropy-atoms.*

A critical note must be made here: objects that have a complexity of three bits (rather than two) cannot and should not be excluded from the model: a 3-bit object cannot be split into smaller separate parts that each would be detectable. However, a four-bit object can –in terms of complexity- be thought to be composed of two 2-bit entropy atoms. Therefore, the above statement is an over-simplification. If we name entropy-atoms 'bi-bits', recognizing that these are the simplest possible detectable entities, we can introduce 'tri-bits' as objects with next higher level of complexity/entropy. Thus we can enhance the above statement as follows:

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

The question would be how one could differentiate between a 'bi-bit' and a 'tri-bit': in both cases the incoming information is a bit-stream at some rate. Regardless this, 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'). These quanta are non-relativistic, equal to all, and

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therefore universally shared between all systems of units of measurement.

Any object's complexity/entropy/heat capacity can be expressed in Bits, whereby 'n' is an integer number ≥ 2.

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

$$S\ (in\ Nat) = n.k_B.\ln(2) \quad ,n \geq 2 \qquad (17)$$

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 is also expressed in Bits, and is equal to:

$$S\ (in\ Bits) = n.k_B \quad ,n \geq 2,\ (k_B = 1\ Bit) \qquad (18)$$

The above two equations are universal, since the 'nat' and the 'bit' are universal.

In Metric Physics k_B may also be expressed in J/K, and the entropy/complexity/heat capacity is then also expressed in J/K. In such case it would be equal to:

$$S\ \left(in\ {}^{J}/_{K}\right) = n.k_B \quad ,n \geq 2,\ \left(k_B = 1.3806488\ \times 10^{-23}\ {}^{J}/_{K}\right) \qquad (19)$$

In the above J/K case, if one multiplies the entropy of a body with its temperature in Kelvin, one gets its 'heat' containment in Joules. This 'heat' containment does however not address the energy that is contained via Einstein's $\mathbb{E} = \mathrm{m}.c^2$.

In a parallel approach, to find the Package content of a single entropy-atom, one must multiply the entropy value of a body with its temperature, expressed in $^0T_{CP}$ per equation (16). Thus, one entropy-atom (n=2), having a temperature of 1/2ln(2) $^0T_{CP}$ (temperature unit of measurement per equation 16) contains 1 Package. Thereby the temperature 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 is more than just the summation of the individual entropies. The reason is, that within the body the entropy-atoms will have extra degrees of freedom (can have different states) relative to each other (as opposed to being 'frozen' into some crystal structure). Per Planck's equation that introduces extra 'ensemble-entropy' that is to be

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associated with a macroscopic ‘ensemble-temperature’.

Based on Planck’s equation $= h.v$, the content of 1 Package is also associated with a ‘frequency’ of 1 C^{-1}, see equation (11). That ‘frequency’ is to be seen as an incoming bit-rate.

Perhaps the most important binding element here is that the gravitational force is to be seen as a result of an incoming stream of information. The gravitational force is proportional to the associated incoming bit-rate.

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4. Gravity depends on temperature.

Per Einstein, in Metric Physics the mass of an object does not depend on its temperature. Consequently, the gravitational force between two objects is independent of the temperature of objects.

The Crenel Physics model introduces 'mass' as a dimension of the Package, just as 'energy' and 'frequency' are. The model thereby follows main stream physics a long way. The relationship with Planck's universal units of measurement is tight.

The Crenel Physics model implies however -as a new consequence- that whatever physical laws are 'mass' based (such as the gravitational force and Newton's laws) should actually be 'Package' based. The relevance is that the Package content of a body embeds a broader concept. This content depends on temperature.

Entropy-atoms were introduced. At this point there have been no aspects in the model to address the temperature of entropy-atoms. This temperature is not to be confused with the macroscopic temperature of a body. Perhaps this entropy-atom temperature is universally equal. This would then explain why the gravitational force between entropy atoms would be universally equal. Perhaps it can be associated with Cosmic Background Radiation. The Crenel Physics model introduces an extra dimension that allows gravitational forces to vary based on temperature differences between entropy-atoms, while nevertheless the gravitational constant remains a universal constant.

The model furthermore implied an additional impact of macroscopic ensembles of entropy atoms, associated with macroscopic temperature:

The 'Package' containment of an object (P_{Object}) is the outcome of

1. counting the contained entropy-atoms multiplied with their respective atom-temperature(s), plus
2. the heat-capacity/complexity/entropy of that body multiplied with its macroscopic temperature.

This is expressed in the following equation whereby the option of

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expressing Boltzmann's constant in 'bit' has been opted:

$$P_{Object} =$$

$$\sum_{n=1}^{n}(2\ bit \times\ T_{CP(Entropy-Atom)}) + heatcapacity \times T_{CP(macroscopic)} \qquad (20)$$

The equation for gravitational force is to be written as:

$$F_G = \ \ G_{CP}\ \times \frac{P_{Object1} \times P_{Object2}}{d^2} \qquad (21)$$

The result of equation (20) is to be substituted in equation (21), for both the Package containment of Object1 as well as Object2.

Verification of the temperature dependency of the gravitational force might be possible by studying details of gravitational forces in the cosmos.