High-Energy Economics

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1 Abstract

In this paper, we outline a theoretical currency which takes advantage of Lorentz transformations, Heisenberg's uncertainty principle, Schrödinger's equations and several other principles of quantum physics. We named this currency "Laplacian" after the mathematician Pierre-Simon Laplace and its symbol is $\triangledown$. This is not to be confused with ∇, the Laplacian operator. In this paper, use of the word and the symbol will only refer to the currency. The value of a Laplacian is linked to the value of an 18 karat solid gold cylinder with a cross-sectional radius of πcm and a height of πcm, for a total volume of $\pi^4 cm^3$. This cylinder will henceforth be referred to as the "Laplacian Coin".

2 One-Dimensional Laplacian Space

Although their value is linked to that of a gold coin, we model the Laplacian as a single relativistic particle which exists in a one-dimensional position space. They do not interact with each other or experience any fundamental interactions. Each has a position and a velocity (its mass is irrelevant for reasons to be explained later). This one-dimensional space is finite in length and each unit line segment corresponds to a user of the currency. As such, when another user registers to use the currency, the one-dimensional space expands. When there are L registered users, the space ranges from $x = 0$ to $x = L$. The space is curved like a circle such that the points at $x = 0$ and $x = L$ are essentially the same point. Figure 1

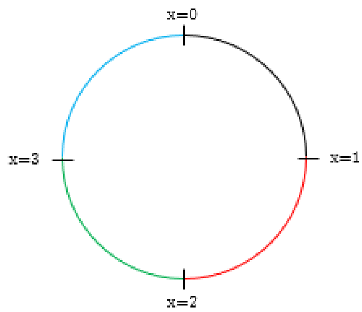

Figure 1: A visual representation of the one-dimensional space with $L = 4$

shows an example of one way of visualizing this space for $L = 4$, but a similar setup would apply for any positive integer value of L. In future, for the ease of graphing, this space will be represented by a straight line but it is important to keep in mind that the two end points join up. Each line segment has an n value, which corresponds to its starting x coordinate. For example, the line segment defined by $1 \leq x < 2$ has an n value of 1. Each Laplacian exists in one of these line segments and as such also has an n value corresponding to the n value of the line segment in which it exists. For example, a Laplacian with a position of 4.8 has an n value of 4. A user owns every Laplacian within their own line segment. Each unit (the length of an individual line segment) is equivalent to 37474057.2 meters, and as such the speed of light c is $8/s$.

3 Valuation of a Laplacian

When a user attempts to sell a Laplacian in their own space, its value must be calculated. Its value is equal to that of a Laplacian Coin with the velocity of the Laplacian being evaluated. Since the resting density of gold is $19.32g/cm^3$, the resting mass m_0 of a Laplacian Coin is $19.32\pi^4 g$. Using a Lorentz transformation, we can calculate the mass m of the coin when its velocity is k.

$$m = \frac{m_0}{\sqrt{1 - \frac{k^2}{c^2}}} = \frac{19.32\pi^4 g}{\sqrt{1 - \frac{k^2}{64s^{-2}}}}$$

Using this new calculated mass and the current price of gold[1] we can calculate the value of the Laplacian. However, until measured, the velocity of the Laplacian is uncertain. It has a velocity wave function which acts as the square root of the probability density function of possible velocities. A Laplacian's velocity wave function $p(x)$ can be controlled to a degree using the Laplacian's v value. This can be any real number greater than or equal to $\frac{1}{2}$ and the owner of a Laplacian has control over its v value. The higher the v value is, the more certain the velocity of the Laplacian is. Figure 2 shows how

Figure 2: $p(x)$ for $v = \frac{1}{2}$, $v = 1$ and $v = 10$ respectively from left to right.

changing a Laplacian's v value changes its velocity wave function. In general, increasing v results in the velocity being more likely to be greater when measured, resulting in the Laplacian having greater value. The wave function is defined as follows:

$$p(x) = \begin{cases} \sqrt{\frac{v}{2}} sin(\frac{\pi v}{4}(8-x)) & \text{if } 8 - \frac{4}{v} < x < 8, \\ 0 & \text{otherwise.} \end{cases}$$

The expected velocity k_e of the Laplacian (the velocity with the highest probability) is defined as follows:

$$k_e = 8 - \frac{2}{v}/s$$

Therefore, the expected value Q_e of the Laplacian is as follows:

$$Q_e = \frac{m_0 G}{\sqrt{1 - \frac{{k_e}^2}{c^2}}} = \frac{19.32\pi^4 gG}{\sqrt{1 - \frac{(8-\frac{2}{v})^2}{64}}}$$

In which G is the current price of gold per gram. Below is a table of values for v and Q_e, assuming $G = \$30.77/g$.

v	Q_e
0.5	\$66865.71
1	\$87547.77
10	\$260603.69

4 Ownership of a Laplacian

From Section 3, it seems clear that a greater v value is better when selling a Laplacian, because it results in a higher probability of having a more valuable Laplacian. However, the Laplacian has a reciprocal relationship between uncertainty in velocity and uncertainty in position (similar to that in Heisenberg's uncertainty principle) which means that a greater v value isn't always better. Similar to the velocity, the position of a Laplacian is also uncertain. Its position wave function $\psi(x)$ is similar to the velocity wave function but with two key differences. One of them is that an increase in v, instead of decreasing the uncertainty, increases it. Figure 3 shows the effects of increasing v on the position wave function. The position wave function is defined as follows:

$$\psi(x) = \begin{cases} \sqrt{\frac{1}{v}} sin(\frac{\pi}{2v}(x + v - n - \frac{1}{2})) & \text{if } n + \frac{1}{2} - v < x < n + \frac{1}{2} + v, \\ 0 & \text{otherwise.} \end{cases}$$

[1]At the time of writing, this is $\$30.77/g$ and as such this is the figure we will be using throughout this paper, but in practice, this would have to be updated live

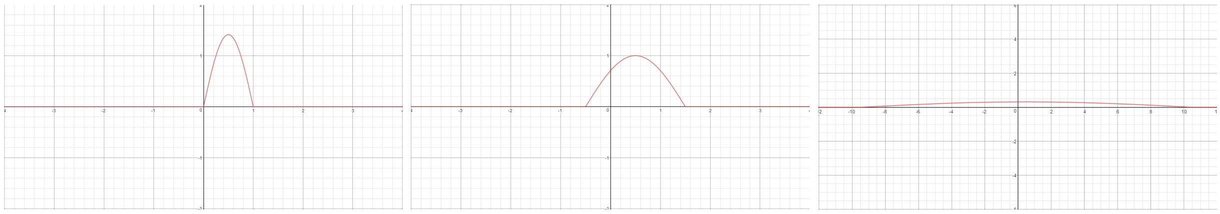

Figure 3: $\psi(x)$ for $v = \frac{1}{2}$, $v = 1$ and $v = 10$, with $n = 0$ for all, respectively from left to right.

As you can see, another key difference of the position wave function is that it is dependent on the Laplacian's n value (the index of the line segment in which it exists). The peak of the wave function always exists at $n + \frac{1}{2}$, and as such, this is its expected position. However, for $v > \frac{1}{2}$, there is a nonzero chance that when the Laplacian is measured, its position is less than n or greater than or equal to $n + 1$; in other words, the Laplacian is not actually within its line segment. This means that when a user is measuring the value of a Laplacian they own, there is a chance that they don't actually own it anymore. When this happens, the n value of the Laplacian changes to the n value of the line segment in which it now exists, and as such it is now owned by whoever owns that line segment. You can calculate the probability Ω of still owning the Laplacian when you measure it like this:

$$\Omega = \int_{n}^{n+1} \psi^2(x)dx$$

Below is a table of values for v and Ω.

v	Ω
0.5	1
1	0.82
10	0.01

Due to the circular nature of the one-dimensional space, the new n value for the circle can be calculated from its measured position x in the following way:

$$n = \lfloor x \rfloor \bmod L$$

Where L is again the number of registered users. If, when selling a Laplacian, it changes line segment, the sale is voided; the Laplacian is not sold, but instead simply changes owner and n value.

5 Fairness in Distribution

This system of losing Laplacians to one's neighbours in the one-dimensional space creates an inequality in the sense that a user is likely to gain more Laplacians if their neighbours have many Laplacians or spend them more frequently. To combat this, imagine that the line segments are being randomly shuffled every time a transaction is made. The effect of this is that every time somebody loses a Laplacian, it has an equal chance of going to each of the other users. For example, when the user who owns line segment 3 sells a Laplacian, all of the line segments are shuffled and only then is the position of the Laplacian measured. If the Laplacian is still within that user's line segment, which may now be line segment 5 for example due to the shuffle, the value is then calculated and that much money is given to the user, after which the Laplacian ceases to exist. If the Laplacian has moved into a different line segment, it goes to the owner of that line segment. Note that when the line segments are shuffled, the Laplacians stay with their original line segments, i.e. if line segment 8 becomes line segment 2, all of the Laplacians with $n = 8$ change their n values to 2.

6 Buying Laplacians

When a user attempts to buy a Laplacian, they are charged an amount equal to the valuation of a Laplacian with $v = \frac{1}{2}$. This ensures that once they buy the Laplacian, there is a 100% chance that they own it. This new Laplacian is valued using the same process by which a Laplacian would be valued when being sold; its velocity would be calculated from its velocity wave function and from that, its value would be calculated.

7 Conclusion

The Laplacian is a unique currency because each one could be worth a different amount when they are measured. One user with $\triangledown 2$ may have less money than another user with $\triangledown 1$, but this cannot be determined until a transaction takes place. Also, it is entirely possible to start with $\triangledown 0$ and by simply waiting, accumulate Laplacians from other users losing them to you. Another unique feature of the Laplacian is that its owner has some influence over its value — its v value. The user has to strike their own balance between making the velocity of their Laplacians likely to be higher (thereby making the Laplacians worth more) and having reasonable certainty that when they come to use it, they still own it. Though it is unlikely that this currency will become widely used, it still provides an interesting platform to experiment with how commodity-based currency would function at high energy levels.