# Relativistic Interpretation of Time and its Quantum Model

Manuel Urueña Palomo

A simplified visual representation of time curvature and space curvature is postulated regarding general relativity and, due to the traversability of the time dimension depending on energy, and there is an attempt to define what time is in both quantum mechanics and field theory, presenting suitable particle dynamics. Although this representation does not invalidate the nowadays model, it is concluded that time is a special dimension in our universe, and by its correct interpretation and unification in different theories, many other physical enigmas can be theorized, based on such conception of time and the signs of the mathematics in related theories, such as the gravitational singularity problem.

Regarding the shape of the universe initially with a positive curvature (spherical shape), according to the sphere of an imaginary time history without boundary that leads to a real time expansion, beginning in one point in an inflationary manner[1], with the three-dimensional space as we know it in the bidimensional surface of that sphere (Figure 1.1 and 1.2), that lacks of thickness, we can place time as another dimension representing the radial vector of spherical coordinates, with its centre in the inside of the sphere.

This time vector will be considered as another dimension and would be useful to compare it to an accelerated growing vector of one of our space dimensions:

> We can not only describe different speeds that our space accelerating vector has had during his path, but also different instants during its route. Placing time instants of "time" in our time dimension might be a difficult task and may require a reference time interval such as Planck time, but we will only need the essential idea for the next explanations. (Figure 2.)

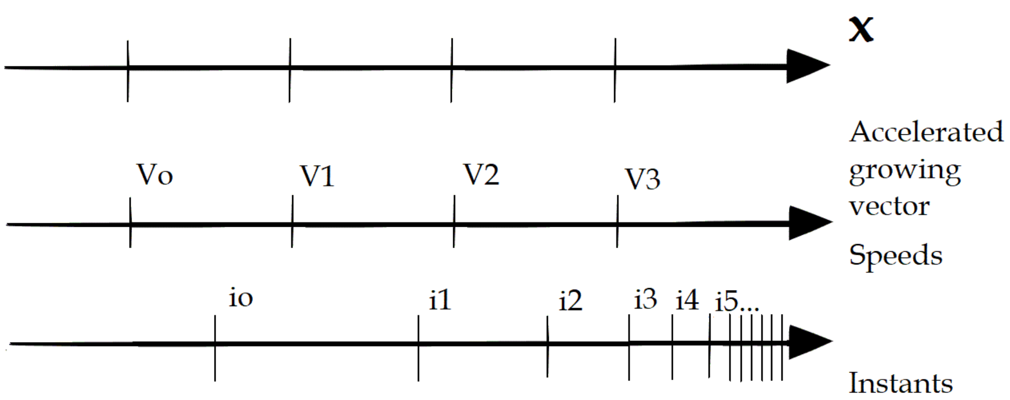
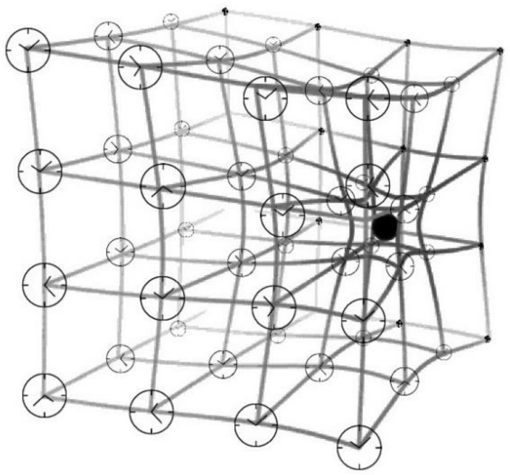



Figure 2. Time as a vector

Back to our model, if we inflate the sphere, leading to a metric expansion of its two-dimensional surface (relying on the evidence of way the universe expands), it would be visualized as an increase in the value of the magnitude of the time vector. We can imagine now each time instant as infinitesimal layers of our sphere growing in number towards the exterior. This matches the common representation of time as another dimension (Figure 1.3) and the fact that the centre of the universe could considered be any point in space but in the past.

The only requirement to understand this model is to imagine the two-dimensional surface of the sphere's layer as a three-dimensional space, meaning that the in the real representation of our world, every single point of the three-dimensional space would have a different value for the time vector, which would be impossible to visualize by us:



This visualization matches what a four-dimensional feature would look like in our three-dimensional space, with a magnitude appearing suddenly in our space but without letting us know where does it come from. Thus, we are unable to see the complete fourth dimension, that is, the dimension of the radial vector that represents time, but only one layer of it. Thankfully, we can relate those magnitudes geometrically to our space by the Einstein's general relativity theory.[2] (Figure 3.)

Figure 3. Dimensional visualization of time (intrinsic curvature)

If every instant of past time and every smaller speed time is placed in an internal layer, it would only be necessary that mass, or more specifically momentum (energy), could bend this sphere's surface in such a way that a point in the surface (which is a three-dimensional point in our world) would be moving against the positive sense of the time vector. Such bending would only be well represented considering those layers as time velocities instead of time instants (onward, we will consider the magnitude of the time vector as a measure of time speeds). (Figure 1.4)

Depending on the way the acceleration of the expansion of the universe occurs (specifically if there is jerk), these speed layers would be equally distanced, or not. But time instants, that should also be considered and in which the Planck time should be taken into account, would not be equally distanced for sure, and we should find a greater number of them the further we go from the time origin. (Figure 1.5)

Time would then pass slowly in the point of the space in which the curvature is deeper compared to another point with a bigger radial distance from the centre of the sphere (they would be assigned different speed times), coinciding with the general relativity theory.[2] In the case of considering an static mass and the required relative point of view by which it does not move and change the curvature of space, it would be situated in a different time speed compared to another smaller mass in a different point of space, so time in the first point would pass slowly than in the other. This conclusion is reached by using an external reference system, that is, looking at the sphere from outside (Figure 1.1), and if applied to our space, should fit our new reference system.

An easy visualization would be imagining the typical representation of the time of the universe, dragging it on three dimensions and considering the bidimensional surface as three-dimensional, so the dimension of time is added. (Figure 1.6) By this way, space and time will not be treated as one, but as two different conceptions closely and always related, and initially, everything in the universe would always be moving in time (for every point of space there will be a different magnitude of the radial growing vector of time in the case that there is not a mass or energy that slows this growth) and consequently always moving in space according to the mixture of the movement between time and space of the general relativity theory (explanation of gravity).[2]

Due to the progress of the accelerated expansion and time, and the different treatment of time for different space points, its acceleration could tend to minimize the bigger deformations of mass and energy, tending to soft the deeper peaks and leading to a better and more balanced mass and energy distribution towards the equilibrium. This suggests that it could be a another explanation for the second law of thermodynamics and the maximization of entropy (closely related to time) without probabilities, and not only the fact that the expansion of the space between particles should be considered, answering the question *"why the direction in which entropy increases is the same in which the universe expands?"* formulated by Stephen Hawking,[3] even though this may not be an unbreakable law if there is a major cause whose effect would be the opposite.(Figure 1.7)

The relative times between different relative systems would explain and confirm special relativity. For example, a space ship travelling at almost the speed of light from the Earth to Pluto would have a very big energy (momentum) and would be assigned a lower speed of time (time dilatation), so in his reference system, he will conclude he has reached Pluto much quicker than he expected, although he has travelled the correct distance for an external observer, who would conclude that the distance travelled by him should have stretched considering the observers time speed and the space ship speed. That is because we are now considering time a variable feature for different points of space.

If this interpretation is not correct, then space should compress depending on the speed and direction as a reaction to that speed (or energy effect), and such compression of the space may have an effect on the movement of the time vector (special relativistic effect). (Figure 1.8) Another hypothesis is described in Figure 1.9, in which the discrete movement of a particle at the speed of light would not feel the pass of time because in every step, it is going to be situated in the future time instant of its next position, jumping to future instants and not been influenced by the passing time (a particle travelling faster than the speed of light would be moving to the future). This matches the mathematical definition of time, because light cannot deform space. If for the photon time does not run, that is, it moves together with the time vector, the speed of the vector would be hidden in that speed of light. For a space-time interval;

$$\Delta s^2 = -c^2\Delta t^2 + \Delta x^2 + \Delta y^2 + \Delta z^2$$

Notice that time is multiplied by the speed of light (and together, to the power of two). This would be equivalent to the speed in time of a static point in space in the space-time diagrams.

By this model, not only time prevents everything happening at the same instant, but also it prevents everything to exist in the same point of space (for a zero value of the radial vector, all existing matter would be in a single space point).

Even though that the spherical universe solves the problem of infinity among the other options, inside its three-dimensional space, when moving forward in one direction, you would return to the original point of the journey. This curious phenomenon can be visualized in our three-dimensional world (because the representation in Figure 1.1 is approximated with just two spatial dimensions) imagining at first one cube in which inside volume exists everything contained in the universe, and second, around that cube, many other identical cubes (with same content and simultaneous events), in a way that if something crosses from one cube to another, it appears in the original cube but in its other side, existing always in all cubes and matching three-dimensionally with the return in the spherical universe model. In this example we would be facing again the same problem because we should be considering infinite and identical cubes, which shows again that it isn't a pure representation of reality but just a tool to understand it.

In case of having a very small sphere, we could intuit that the light that our back is emitting could turn around and reach us in our face. Not only we would be seen ourselves in the distance (by the intrinsic curvature of space), but, if we extend our arm to touch ourselves in the back, we would actually be doing it literally. We can even think that also the same light hitting our face could be turning around and reaching us again, so we would be seen a loop similar to the one that happens when facing two mirrors. Even though it would look as another case of infinity, we know there is only one version of ourselves and the others are just light showing past instants of time (Figure 1.3) that have been going around the sphere. It should be noticed that we have considered square volumes (cubes) but the logical option should be considering spheres.

A further modelling will make us wonder what would happen if a deformation by a certain energy could be so that the speed of the moving time vector would be countered for an observer in that point and with that system of reference. In a discrete movement of the time vector, this would be considered as if that point of space would be jumping to the previous time instant in each step. That region of space in which time for itself tends to zero and time tends to infinite for an external observer is what we call a black hole: moving in space becoming partially moving in time, represented as the coincidence of the space slope and the direction of the time vector, and represented by the solution to the Einstein's field equations by the Schwarzschild metric [4]:

$$ds^2 = -c^2 d\tau^2 = -\left(1 - \frac{r_s}{r}\right) c^2 dt^2 + \frac{dr^2}{1 - \frac{r_s}{r}} + r^2 \left(d\theta^2 + \sin^2\theta \, d\varphi^2\right) \quad r_s = \frac{2GM}{c^2}$$

in a way in which substituting and simplifying we obtain;

$$ds^2 = -\left(1 - \frac{2GM}{c^2 r}\right) (c\mathrm{d}t)^2 + \left(1 - \frac{2GM}{c^2 r}\right)^{-1} \mathrm{d}r^2 + r^2 d\Omega^2$$

so that, for $r < r_s$ (Schwarzschild radius), the terms $\left(1 - \frac{2Gm}{c^2 r}\right)$ turn to be negative, and by that change, $dt^2$ nges its sign to positive (space also, but only its radial component, not its angular or orbital, and so, partially). This change in the sign for the time coordinates will determine that particles inside the black hole would behave as if they were antiparticles, and matter as antimatter with antigravitational interactions, which will be explained onwards.

Space beyond this limit would be the same, and very distorted due to the vast energy, but it would be moving in the opposite sense in the time dimension, that is, reducing its assigned magnitude of the time vector in contrast to the usual sense of the time's vector progress. Thus, the event horizon, would not be more than the place in space in which time begins to move backwards, and would not tend to infinity but to a reference value, which determines the sense of time in the next instant. Consequently, time "flows" backwards beyond this region (which in our sphere model is represented as a circumference and in the real three-dimensional world as a sphere). (Figure 1.10)

> Following this model, on the other side of this region there is space with a different shape which could expand or not, depending on the mass (energy) contained (absorbed) and the thermodynamics and energy conservation of the black hole. This region would have to contain a white hole inside, radiating energy. The author suggests that time should be reversing progressively, starting from zero near the white hole, and physical events would tend to the equilibrium and order because of the second law of thermodynamics and its time dependency, or the fact that the time change could affect matter turning it into antimatter with repulsive gravitational forces, which will be explained onwards. The shape of this region should be restricted by the white hole, and space should be very distorted at its surroundings. A surface-based model is suggested by matching the correlations of deformations between the sphere's model properties of that space and the real space dimensions (considering two paths named "1" and "2"). Time placement in this model is also proposed in a suitable manner. (Figure 1.11) The distorted curvature of the space around the white hole would prevent energy from escaping this region of space.

As stated in the beginning, the model is based on the hypothesis of a spherical curvature universe, but we should consider the possibility of the new created space been wrinkled by energy in the past and in the present, leading to a better matching of an inflationary expansion and a later slowed down expansion, if a flattered sphere is also considered.[1] This roughness would explain the CMB measurements[5] and, if situated in the flattest part of the sphere, the small curvature measurements of our universe.[6] (Figure 1.12)

The author intuits that the magnitude of the time vector might not depend on the depth of the space point but maybe on the curvature (slope) of the space deformation and the speed deformation of the space would match the speed of light as stated by recent evidence of gravitational waves.[7] In addition it is suggested that antimatter's negative energy solution from Dirac's equation;

$$\psi = u(E, \vec{p}) e^{i(\vec{p}.\vec{r} - Et)}$$

taking into consideration the time dependence;

$$\psi = u(E, 0) e^{-iEt}$$

with solution for negative energy with p=0;

$$E_0 = -mc^2$$

gives us two spinor states;

$$\psi_3 = \begin{pmatrix}0\\0\\1\\0\end{pmatrix} e^{+imt}; \text{ and } \psi_4 = \begin{pmatrix}0\\0\\0\\1\end{pmatrix} e^{+imt}$$

that can be interpreted as positive energy with negative time (particles moving backwards in time), following the Feynman-Stueckelberg interpretation[8];

$$\begin{aligned} v_1(E,p)e^{-i(Et-\mathbf{x}\cdot\mathbf{p})} &= u_4(-E,-p)e^{i(Et-\mathbf{x}\cdot\mathbf{p})} \\ v_2(E,p)e^{-i(Et-\mathbf{x}\cdot\mathbf{p})} &= u_3(-E,-p)e^{i(Et-\mathbf{x}\cdot\mathbf{p})} \end{aligned}$$

with $p \neq 0$;

$$Et - \boldsymbol{p}\cdot\boldsymbol{x}$$

$$\begin{aligned} -E &\to E \\ t &\to -t \\ \boldsymbol{p} &\to -\boldsymbol{p} \end{aligned}$$

or particles that would bend space towards the interior of the sphere, approaching past instants of time, so that antimatter and negative energy is the already known and existing matter we have always considered, and the other solution which involves positive energy with a positive time (moving forward to the future) would bend space towards the exterior, and would be the revealed one by Dirac in 1928 (supposing a positive curvature, because if it was negative, the original interpretation could be right). Thus, the distinction between the two kinds of matter (and energy) would only be the sense of the deformation of the sphere (same way of space deformation and gravitational effect but in the other sense!), that is, the sense of time deformation. (Figure 1.13) This physical phenomenon has not been detected due to the difficulties of measuring such small gravitation effect of the small mass of the created matter in experiments. The author suggests that this antigravity effect would be consistent with the model if an antimatter particle inside a curved space-time by ordinary matter would be following the traditional paths even though there would be a very small counter curvature effect because of the small mass of the particle. Photons with no mass should be considered their own antiparticles with positive time and no space bending, following Figure 1.9. The combination of both deformations or energies would determine the way the sphere will change, either expanding or contracting (dark energy enigma), and antimatter event horizons could not be formed because there would not be a change in the sense of time in that deformation, and if there are repulsive gravitational forces (antigravity), that antimatter could not be compacted in infinite density points, so no singularities could exist.

Such antigravitational effect would be present in Newtonian physics, in a way that if the gravitational forces between two particles with the same negative mass (like the negative energy solution in the development of the Dirac equation) follow the equation;

$$\vec{F}_{12} = -G\frac{m_1 m_2}{r_{21}^2}\hat{r}_{21}$$

in a way that both negative signs in the masses are cancelled and we obtain the traditional forces of the same value, equal direction and different sense (attractive) for every particle, the acceleration equation;

$$\vec{a} = \frac{\vec{F}}{m}$$

results in equal accelerations, in the same direction, but different repulsive sense, taking into account the negative of the inertial mass for each particle. [11] This indicates that both particles would experience a repulsive effect, equivalent to antigravity, in a way that the weak principle of equivalence holds (a negative mass would have the same gravitational and inertial mass). For two particles with different mass sign, we should now consider its distance as the space-time interval;

$$(\Delta s)^2 = (\Delta ct)^2 - (\Delta x)^2$$

due to the fact that they would be in different time positions (one in the future and the other in the past, relatively), and, if that interval would be zero like it happens in other cases, the Newton's gravitational force equation would be;

$$\vec{F}_{12} = -G\frac{m_1 m_2}{(\Delta s)^2}$$

resulting in a force of value zero, and consequently a zero acceleration, solving the problems of perpetual movement and infinite energies that rise up when trying to apply the distance only in space. Then, two different particles in mass sign would not interact gravitationally and it would be the difference in absolute value of the masses that would allow that interaction.

The advance towards the future or the past for the particles and their interferences between them, according to the conception of time in the quantum mechanics and field theory mathematics must have a precise physical meaning (which is independent of the macroscopic curvature of the universe that is suggested). The Schrödinger equation describes the evolution of the wave function of a particle regarding only one speed of time, the speed of time of reference (usually the observer), without considering the difference in speeds of time between particles depending on their momentum.

If we interpret that, for the antiparticles (classical denomination, that is, considering antiparticles as the particles that surround us, tend to go backwards in time and bend space according to general relativity), "their time flows backwards", we have a macroscopic analogy in our model with black holes, in which time also flows in the opposite sense (backwards). For example, we can imagine that an antiparticle can have different energies (different ways of bending space and thus, time) in different time instants. If we consider the sense of the bending towards the past, that is, tending to the past instant of time, if that energy fluctuated between different instants, a particle could jump to past instants if it had the necessary energy in the instant of time that was before. This matches perfectly with the Heisenberg's uncertainty principle applied to energy and time, because, considering only one instant, the particle would have a determined energy, which could vary a lot to the average energy in different instants, been that average the correct energy measure. (Figure 4.)

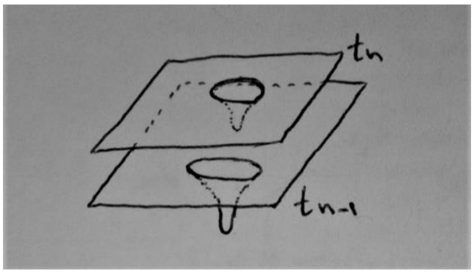



Figure 4. Energy fluctuations of an antiparticle that tend to the past in two different time instants

One of the clear conclusions is that, in quantum scales, if there were small gravitational waves, this would be creating the same effect in space as if we had small masses (or energies), moving back and forward in time instants. Such distortions of the limit between future and past instants (if the present time instant exists) would be happening even in empty space (only space and time) and would match the creation of a virtual particle of positive energy and another of negative energy (every particle at one side of the present instant of time, matching with the extremes of the period of a wave), when instead of particles there would be the same effects that those particles with their mass and energy would be producing in the present instant of time (so no particles could be measured). This explanation would shed light on the fact that the energy to create these waves would be taken from the future (in which we would find part of the wave that counteracts the other part, or to put it simple, a virtual particle). Quantum fluctuations from empty space could explain the variations in the energy of the real particles in different time instants. (Figure 5.)

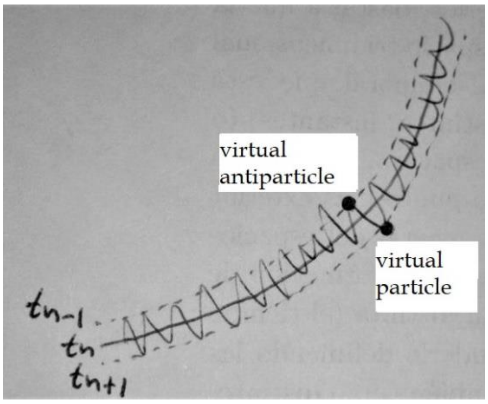



Figure 5. Quantum fluctuations of empty space for a single space dimension (classic denomination)

As explained before, the space deformations by the masses of particles in very small scales would interfere greatly with past and future instants of time, allowing a particle in some instants to move to past or to the future according to its nature and properties, and moving in space in the past or future, so that in the next time instant it would appear in a different space position in our present time. This implies that there is an existing movement in time instants apart from the reference (actual) one, that could explain other phenomena such as the tunnel effect. It should be noted that the effects that an existing particle produces are present in every instant across its deformation, not only in the one that the particle lies, and so, it can be concluded that the particle exists in every instant, but just in one as a particle, that the author considers measurable. (Figure 6.)

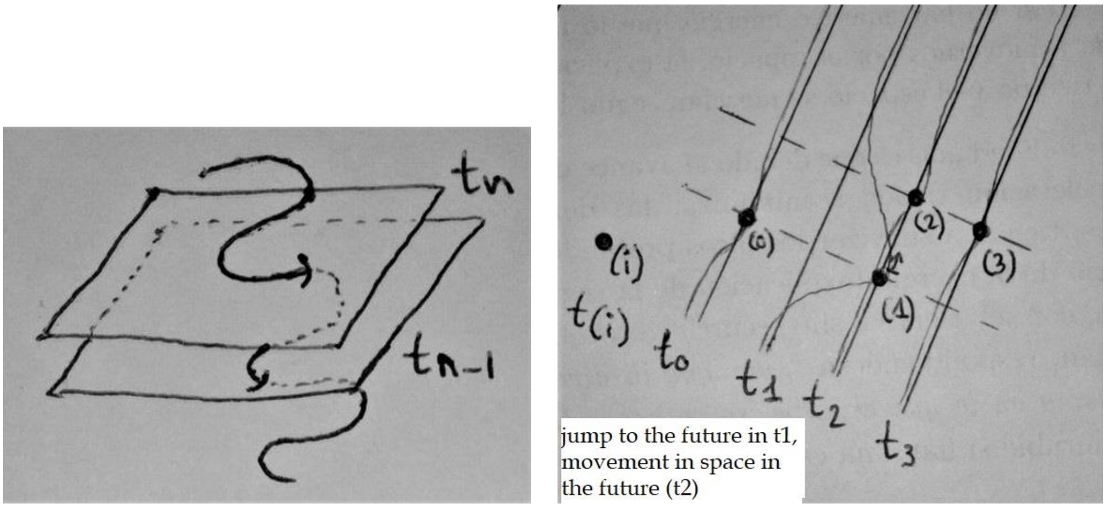



Figure 6. Undulatory movement between time instants and tunnel effect of a particle (classic denomination)

Thus, the probability of finding one particle (in one particular instant of time) could be the description of the movement of the particle between future and past instants of time, collapsing in the present instant of time when measuring due to the fact of the matching of the instant of time of the measure with the one of the process of the measurement. (Figure 7.)

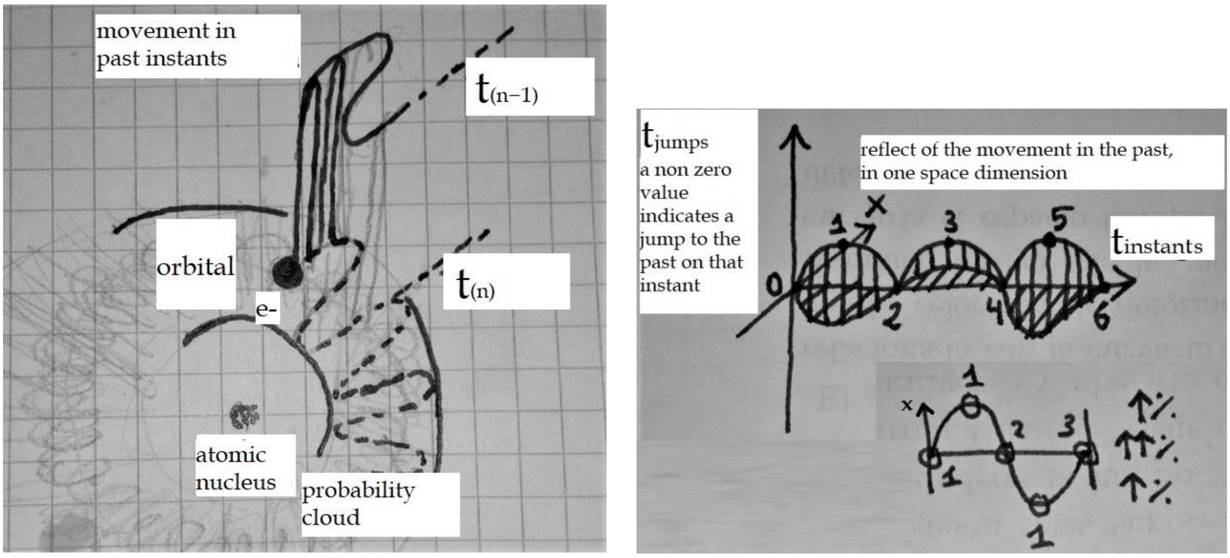



Figure 7. Positron movement in the past (classical denomination, the electron type that we are surrounded by), its movement as a wave in the past and its probability density simplified

Such movement between time instants would create waves that could interact not only with the same particle but with other waves of other particles, explaining phenomena such as the double slit experiment. The movements between instants of time could be modified due to the interactions of the particles and its own wave, creating the quantum probabilistic patterns like some macroscopic scale experiments analogous to the quantum theory demonstrates [9], been these movements more precise than the simplified one in Figure 7.

This would also confirm the Heisenberg's uncertainty principle for position and linear momentum, because to be able to determine with absolute precision the position of a particle would imply to consider only one instant, and not been able to determine its momentum with just one time instant : its momentum (including between instants) could only be determined considering multiple instants, and the more, the better precision. [10]

To avoid the loss of a particle in far away instants of the past, it should, not only tend to the past in space-time when created in the present instant (the true meaning of time in the mathematics), but also travel due to variations of energy (and/or its interferences with the vacuum energy), back and forward in time, probably following a determined oscillating trajectory (in only one dimension, time) (Figure 8.), and that time alone would be moving forward to the future (as the space dimensions increase according to the metric expansion, the time dimension, been closely related to space dimension, could be doing the same apart from the speed of light as stated before when analyzing the space-time interval). (Figure 2.)

$$\hat{H} = \frac{\hat{p}^2}{2m} + \frac{1}{2}kt^2 = \frac{\hat{p}^2}{2m} + \frac{1}{2}m\omega^2 t^2$$

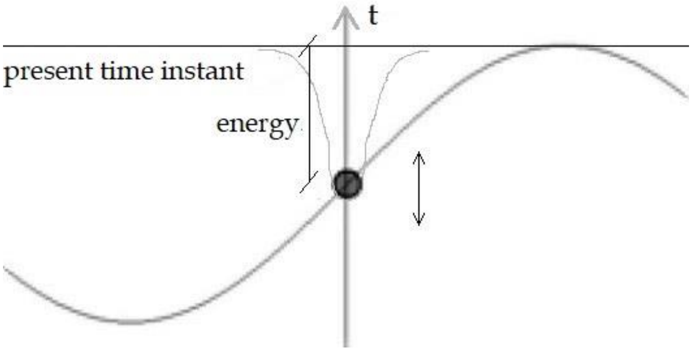



Figure 8. Oscillatory movement in time (one single dimension)

If the process of measurement influences the particle, and that determines that the particle oscillates more frequently in the present instant (considering also the interactions between particles), the author suggests that, isolated particles which usually would be interacting less with photons (the equivalent of measuring) or other particles, could be sinking more deeply in the past, or oscillating more far away from the present instant due to not interacting with the same energy than not isolated ones, would act like if they had more mass when deforming space, and that could explain dark matter. If there was antimatter in intergalactic space, this sinking would be in the opposite sense, and would be growing exponentially if space is expanding, leading to a possible solution to the dark energy as stated in other theories. [11]

The mathematical development of the model is left for the one interested in these ideas, opening the possibility of time to be the one oscillating relatively to the particles, and emphasizing the similarities of the quantum interpretation with the De Broglie-Bohm interpretation, been time the key of the nature of the wave concept and the solution to its difficulties when fitting the observable reality, and also the breaking of the time symmetry.

<u>Cosmological model</u>

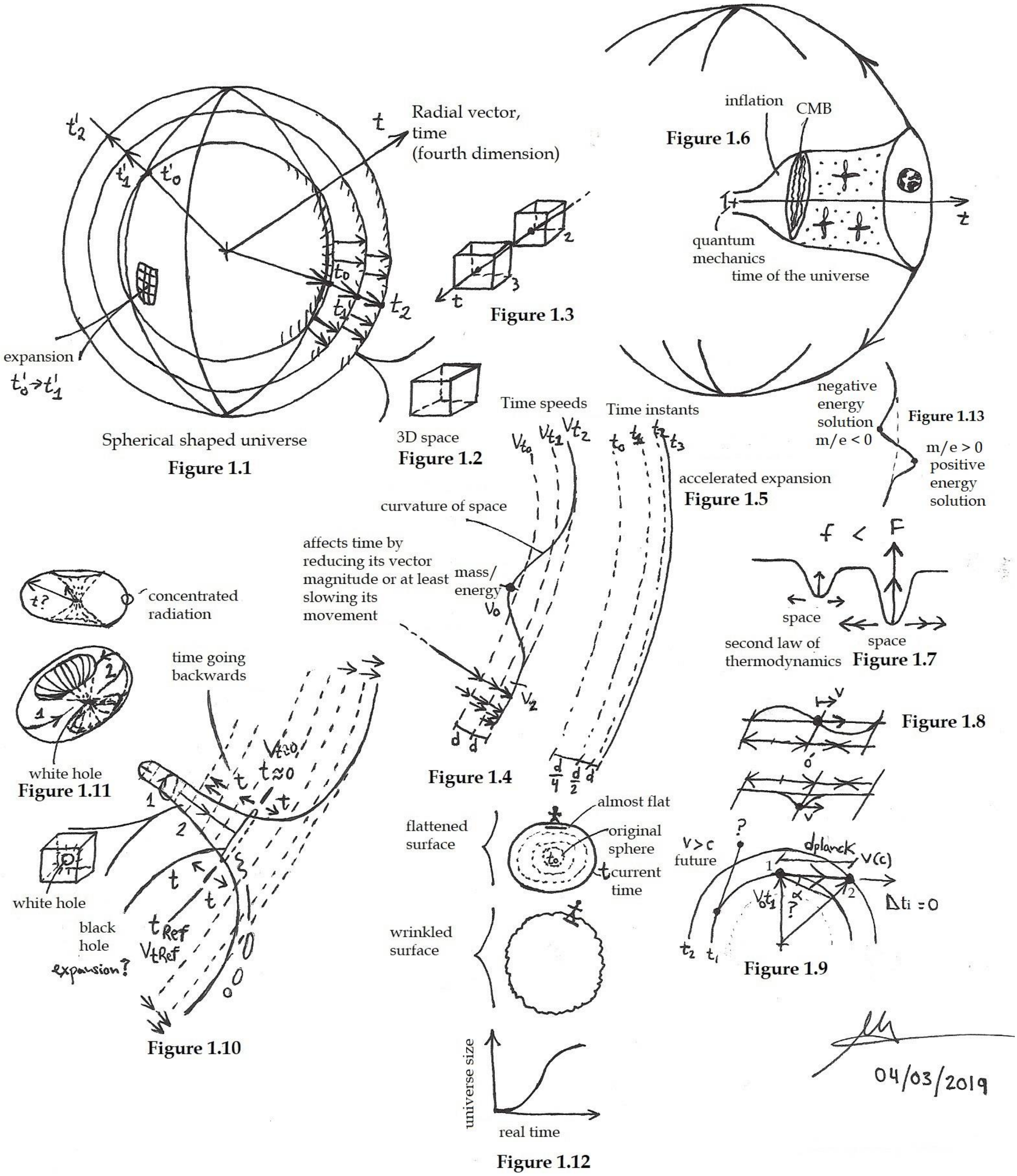



Figure 1. Sketch of the model

# References:

[1] S. W. Hawking, *The Universe in a Nutshell*, Bantam Spectra, (2001)

[2] A. Einstein, *Zur allgemeinen relativitätstheorie*, Sitzungsber. preuss. Akad. Wiss. (1915)

[3] S. W. Hawking, *A Brief History of Time,* Bantam Dell, (1998)

[4] K. Schwarzschild, *Über das Gravitationsfeld eines Massenpunktes nach der Einsteinschen Theorie*, Sitzungsber. Preuss. Akad. Wiss. Berlin, pp.189-196, (1916)

[5] R. W. Wilson, *The Cosmic Microwave Background Radiation*, Holmdel, NJ (1978)

[6] Planck Collaboration*, Planck 2015 results. XIII. Cosmological parameters*, (2015)

[7] LIGO Scientific Collaboration and Virgo Collaboration, *Observation of Gravitational Waves from a Binary Black Hole Merger*, (2016)

[8] Lancaster, Tom; Blundell, Stephen J.; Blundell, Stephen., *Quantum Field Theory for the Gifted Amateur*, (2014)

[9] M. Harris, J. Moukhtar, E. Fort, Y. Couder, and W. M. Bush, *Wavelike statistics from pilot-wave dynamics in a circular corral,* Physical Review E 88, (2013)

[10] Heisenberg, W. Zeitschrift fur Physik, 43, 172-198, (1927)

[11] J. S. Farnes, *A Unifying Theory of Dark Energy and Dark Matter: Negative Masses and Matter Creation within a Modified ΛCDM Framework,* (2018)