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Studies of Santilli's Isotopic, Genotopic and Isodual four Directions of Time[1]

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Abstract. The decades of research by Professor R. M. Santilli saw the advent of iso-, isodual-, geno-, genoisodual- and hyper- mathematics and corresponding lifting of mechanics and quantum mechanics [see for example the refs.: 1, 2]. This then removed a multitude of inadequacies existing in various branches of science e.g. general and special relativity, quantum mechanics, quantum chemistry, astrophysics, cosmology, particle physics, nuclear physics, and so on. Thus we can safely say that the new mathematics of Santilli produced new sciences for a new era. Santilli has discovered [see for example the ref.: 3] for the first time that there are four directions of time's arrow and not two asserted earlier by Eddington [4]. Herein we have briefly reviewed Santilli's *isotimes, genotimes and genohypertimes*. To this list we have added *genothermodynamic times* identified for the first time by the present author [5] by reanalyzing the genononequilibrium thermodynamics of coupled processes [6].

Keywords: Genomathematics, Lie Admissibility, Irreversible Thermodynamics, Irreversibility, Genononequilibrium Thermodynamics.
PACS: 02.20.Sv; 05.20.-y; 05.70.-a; 05.70.Ln

INTRODUCTION

The celebrated Eddington's time's arrow [4] has only two directions. Human senses too recognize only past and future directions and hence Eddington's time's arrows are considered as an adequate and proper description commensurate with our physical observations. Notice that the mathematics involved herein is the conventional Lie algebra that uses conventional numbers.

FOUR DIRECTIONS OF TIME

In the scientific history, for the first time, Santilli has identified four directions of time by using iso-, geno- and their isodual- mathematics . These remained unfortunately submerged just because the 20th century Lie algebra was incapable of unearthing the two additional directions of time.

Isotopic Law for Numerical Values of Functions and Isotime

According to Santilli's isomathematics a conventional quantity is *isotopically lifted* as [see for example the refs.: 1–3],

$$A(t, r, p, \psi, \psi^{\dagger}, ...) \longrightarrow \hat{A}(\hat{t}, \hat{r}, \hat{p}, \hat{\psi}, \hat{\psi}^{\dagger}, ...) = \hat{I} \times A(t, r, p, \psi, \psi^{\dagger}, ...) \tag{1}$$

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where $\hat{I}$ is the proposed positive definite *isounit* and is obtained on isotopic lifting of conventional unit, $I = +1$ that is represented as,

$$I = 1 \quad \longrightarrow \quad \hat{I}(t, r, p, \psi, \psi^{\dagger}, ...) = \frac{1}{\widehat{T}} > 0 \tag{2}$$

Thus when a function say $f(r)$ is isotopically lifted to $\hat{f}(\hat{r})$ it has been shown by Santilli that $f(r)$ and $\hat{f}(\hat{r})$ both have identically the same numerical value. This is termed as the *Isotopic Law for numerical values* [1, 7, 8].

On the same lines time t gets isotopically lifted to the *isotime* $\hat{t}$ but now it has its own *isounit*, $\hat{I}_{\hat{t}} = 1/\widehat{T}_{\hat{t}} > 0$. However, in the view of the above stated *Isotopic Law for numerical values* we have numerical equivalence of the conventional time, t_{ext}, and the isotopic time, $\hat{t}_{intr}$ which is intrinsic to the corresponding isospace. Hence, we have,

$$t_{ext} = t_{ext} \times 1 = \hat{t}_{intr} = t_{intr} \times \hat{I}_{\hat{t}} \tag{3}$$

From eq.(3) it is clear that the pace of t_{intr} is not the same as that of t of our universe, t_{ext}. That is when $\hat{I}_{\hat{t}} > 1$ there we have a slower pace of t_{intr} than t_{ext} ($t_{intr} < t_{ext}$) and when $\hat{I}_{\hat{t}} < 1$ there we have faster pace of t_{intr} than t_{ext} ($t_{intr} > t_{ext}$). This is a vitally important discovery by Santilli having far reaching implications say for example for understanding the time evolution of biological complex systems such as seashells.

Directions of Time Based on Iso- and Isodual- Mathematics

However, with the advent of Santilli's isodual mathematics [9] it becomes evident that each physical quantity has its *anti-isomorphic map* called *isodual*. Thus, now we are led to the isodual Lie algebra and hence in isodual setting evidently there would be corresponding future and past directions. Let us elaborate it a little further.

Let us consider an arbitrary quantity A dependent on say $t, r, p, \psi, \partial\psi, ...$ Its *isodual map* is described as,

$$\begin{aligned} A\left(t, r, p, \psi, \psi^{\dagger}, ...\right) \quad &\rightarrow \quad A^{d}\left(t^{d}, r^{d}, p^{d}, \psi^{d}, \psi^{\dagger d}, ...\right) \\ &= -A^{\dagger}\left(-t, -r^{\dagger}, -p^{\dagger}, -\psi^{\dagger}, -\psi, ...\right) \end{aligned} \tag{4}$$

The basic quantity of isodual mathematics is then the *isodual isounit*, namely:

$$\hat{I}^{d} = -\hat{I}^{\dagger}\left(-t, -r^{\dagger}, -p^{\dagger}, -\psi^{\dagger}, -\partial\psi^{\dagger}, ...\right) = \frac{1}{\hat{T}^{d}} < 0 \tag{5}$$

The *isodual isonumbers* are given by,

$$\hat{a}^{d} = -\hat{a}^{\dagger} = -\hat{I}^{\dagger} \times \hat{a}^{\dagger} \tag{6}$$

Now if a is time t then the *isotime*, $\hat{t}$ is defined as [7, 8],

$$\hat{t} = t \times \hat{I}_{\hat{t}}, \qquad 0 < \hat{I}_{\hat{t}} \neq 1 \tag{7}$$

then the isodual time $\hat{t}^{d}$ gets defined as,

$$\hat{t}^{d} = t \times \hat{I}^{d}_{\hat{t}^{d}} < 0, \qquad \hat{I}^{d}_{\hat{t}^{d}} < 0 \tag{8}$$

Notice that ($\hat{t} > 0$) corresponds to future and describes forward motion whereas ($\hat{t} < 0$) corresponds to past and describes backward motion. Similarly in *isodual space* $\hat{t}^{d}$ has future ($\hat{t}^{d} > 0$) and past ($\hat{t}^{d} < 0$) values. But when we view the latter times through our senses the *future isodual time* describes backward motion in future time and the *past isodual time* describes forward motion in past times. This we depict in Figure 1,

New Notions of Time

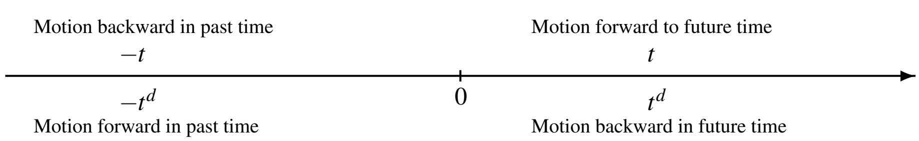

FIGURE 1. A schematic view of the four possible "time's directions".

Although, Santilli through his iso- and isodual- mathematics identified, for the first time, four directions of time but these times follow the time reversal symmetry. That is the forward motion becomes backward motion on reversing the sign of time. Therefore, these four directions of time are not suitable for describing irreversible motions as they do not get reversed on time reversal. This drawback has been removed by Santilli through his geno- and genoisodual- mathematics.

Directions of Time Based on Geno- and Genoisodual- Mathematics

To correctly described irreversibility of motion Santilli formulated genomathematics and its isodual branch. In genomathematics forward and backward motions are described using different multiplying *genounits* for forward and backward motions [10–13]. The first $\hat{I}^{>}$ for the *ordered multiplication to the right* $A > B$, called *forward genoproduct*, and the second ${}^{<}\hat{I}$ for the *ordered multiplication to the left* $A < B$, called *backward genoproduct*, according to the general rules,

$$\hat{I}^{>} = 1/\hat{S}, A > B = A \times \hat{S} \times B, \hat{I}^{>} > A = A > \hat{I}^{>} = A, \qquad {}^{<}\hat{I} = 1/\hat{R}, A < B = A \times \hat{R} \times B, {}^{<}\hat{I} < A = A <{}^{<}\hat{I} = A, \quad (9)$$

where $\hat{S}$ and $\hat{R}$ are respective *genotopic elements*, that is for the forward and backward multiplications respectively. Moreover, we have assumed,

$$A = A^{\dagger}, B = B^{\dagger}, \hat{R} = \hat{S}^{\dagger}, \text{ and } \hat{R} \neq \hat{S}, \quad \text{and hence we have} \quad \hat{I}^{>} \neq {}^{<}\hat{I} \quad (10)$$

Thus it is easy to see that we have correspondingly two directions of time $\hat{t}^{>}$ (for forward motion) and ${}^{<}\hat{t}$ (for backward motion) defined by,

$$\hat{t}^{>} = t \times \hat{I}^{>}_{\hat{t}}, \quad {}^{<}\hat{t} = t \times {}^{<}\hat{I}_{\hat{t}} \quad (11)$$

Correspondingly, the genoisodual multiplying units and forward and backward times are given by,

$$\hat{I}^{d>}_{\hat{t}} = -(\hat{I}^{>}_{\hat{t}})^{\dagger}, \quad \hat{t}^{d>} = t \times \hat{I}^{d>}_{\hat{t}}, \quad {}^{<}\hat{I}^{d}_{\hat{t}} = -({}^{<}\hat{I}_{\hat{t}})^{\dagger}, {}^{<}\hat{t}^{d} = t \times {}^{<}\hat{I}^{d}_{\hat{t}} \quad (12)$$

Thus it is evident that we have following four directions of time using geno- and genoisudual mathematics depicted in Figure 2, As the irreversibility is permitted by the *forward* and *backward genotimes* $\hat{t}^{>}$ and ${}^{<}\hat{t}$ the same gets inherited

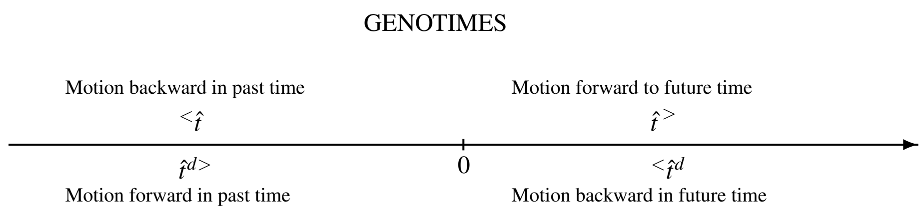

FIGURE 2. A schematic view of the four possible "Genotime's directions". It coincides that of Figurer 1 when forward and backward genounits coincide.

by the corresponding isodual map namely $\hat{t}^{d>}$ and ${}^{<}\hat{t}^{d}$ for antimatter systems. However, in biological systems there we have complex irreversible processes occur ing simultaneously in that some are structure breaking and the other are structure making. The latter ones get amicably described by isodual genotimes without getting involved the features of antimatter [14].

Herein too for the sake of demonstrative clarity we express the first part of eq.(11) as follows,

$$t_{ext} = t_{ext} \times 1 = \hat{t}^{>}_{ext} \times \hat{1}^{>} = t^{>}_{intr} \times \hat{I}^{>}_{\hat{t}} \quad (13)$$

Thus the pace of $t^{>}_{intr}$ would be faster for $\hat{I}^{>}_{\hat{t}} < 1$ and it would be slower for $\hat{I}^{>}_{\hat{t}} > 1$ as compared to our time t_{ext}. The advantage of the genotopic description over the isotopic one is that the irreversibility of the involved processes gets clearly prescribed in the former.

Directions of Time via Genohyper- and Its Isodual- Mathematics

Similarly, Santilli has revealed four directions of time using hyperstructural- and its isodual- mathematics [3] depicted in Figure 3, These are the *multivalued forward and backward genohypertimes* are the ultimate generalization

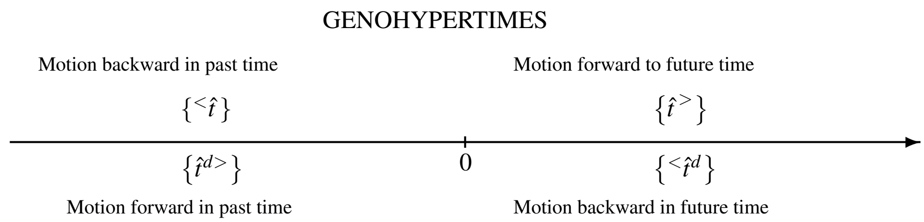

FIGURE 3. A schematic view of the four sets of possible “Genohypertime’s directions". It coincides that of Figurer 1 when all forward and backward genhyperounits coincide.

of arrows of time. These times have been shown by Santilli and Illert [14] help amicably in describing biological growth processes such as the growth of seashells.

Four Genothermodynamic Directions of Time

The second law of thermodynamics determines the natural forward direction of processes corresponding to the future direction of time. It has been shown in nonequilibrium thermodynamics that in coupled chemical reactions one process proceeds in accordance of the dictates of the second law of thermodynamics that drives other chemical process to proceed in the direction forbidden by the second law of thermodynamics. This fact, has been recently used by the present author [5] by way of identifying genothermodynamic directions of time based on above described four directions of time discovered for the first time by Santilli. These directions of genothermodynamic times have been depicted in Figure 4, We stress that one of the advantages of these identified *genothermodynamic times* is that all

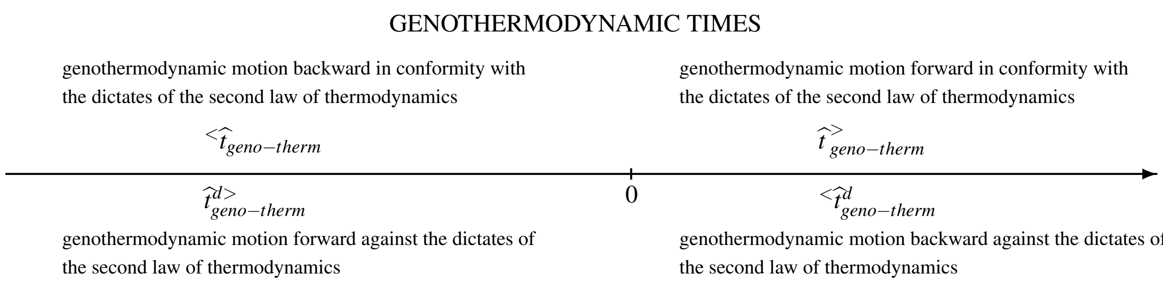

FIGURE 4. A schematic view of the four sets of possible “Genothermodynamic time’s directions".

processes occurring in the respective spaces (that is in geno- and genoisodual- thermodynamic spaces) get described as following the dictates of the second law of thermodynamics as if they are uncoupled processes.

CONCLUDING REMARKS

From the above brief description of four directions of time’s arrow discovered for the first time by Santilli [see for example the refs.: 1–3] by using his iso-, geno-, hyper- and their isodual- mathematics is mile stone in the history of science. Recall that earlier Eddington had asserted that there are two arrows of time directed to forward (future) and backward (past) motions [4]. The advantage of Santilli’s this discovery is far reaching. Let us quote what Santilli himself has repeatedly emphasized taking an example of *isotime* [see for example the refs.: 1–3, 7, 8]:

> *When we look at a seashell in our hands, we perceive it as evolving according to our time, while in reality the seashell could evolve according to an intrinsic time arbitrarily in the future or the past with respect to*

our time, the differences depending on the value of the internal isounit of time. The compatibility of different internal times with our own time is assured by the isotopies because the numerical value of the properly formulated isotopic time (that on a time isospace over a time isofield) coincides with our own time. In different words, consider an external entity, such as a sea shell, or external event in the universe, such as supernova explosion. Their view we perceive via reflected light, by no means, implies that the considered external entity or event evolves according to our own time, since it could evolve in four completely different, forward and backward, future and or past time. This is a reason for my believing that the raising of questions such as "the age of the universe" is an indication of our ignorance vis-á-vis the complexity of nature because, when we include antimatter, the total time of the universe could well be identically null as a condition to avoid discontinuity at creation.

An another advantage of the discovery by Santilli of four directions of time's arrow that has been derived by the present author [5] through development of genononequilibrium thermodynamics is the surfacing out of four *genothermodynamic arrows of time* based on the directions of processes dictated by the second law of thermodynamics. The corresponding directions of time are depicted by $\hat{t}^{>}_{geno-therm}$, ${}^{<}\hat{t}^{d}_{geno-therm}$, $\hat{t}^{d>}_{geno-therm}$ and ${}^{<}\hat{t}_{geno-therm}$. These times are to be used for forward and backward processes occurring in accordance with the dictates of the second law of thermodynamics and for the forward and backward processes occurring by flouting the dictates of the second law of thermodynamics as described in the main text.

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