Chronons, Time Atoms, and Quantized Time: Time Asymmetry Re-Visited

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Abstract

A directional time does not feature in Newtonian mechanics, in electromagnetic theory, in quantum mechanics, in the equations which describe the world of elementary particles (with the exception of the kaon decay), and in some border astrophysical conditions, where there is time symmetry. Yet, we perceive the world of the macro as time asymmetric and our cosmology and thermodynamics explicitly incorporate a time arrow, albeit one which is superimposed on the equations and not derived from them. The introduction of stochastic processes has somewhat mitigated this conundrum.

Time is, therefore, an epiphenomenon: it does not characterize the parts – though it emerges as a main property of the whole, as an extensive parameter of macro systems.

Paper

History of the Chronon and Quantized Time in Physics

The idea of atomistic, discrete time has a long pedigree in physics (**Descartes, Gassendi, Torricelli**, among others). More recently, **Boltzmann, Mach**, and even **Poincare** all toyed with the concept. There was a brief flowering of various speculative and not very rigorous, almost metaphysical or numerological models immediately after the introduction of quantum mechanics in the 1920s and 1930s (**Palacios, Thomson** indirectly, **Levi** who coined the neologism “chronon”, **Pokrowski**, **Gottfried Beck, Schames, Proca** with his “granular” time, **Ruark, Flint and Richardson, Glaser and Sitte**).

Oddly, luminaries such as **Pauli, de Broglie**, and especially **Schroedinger** were drawn into the fray, together with lesser lights like **Wataghin, Iwanenko, Ambarzumian, Silberstein, Landau, and Peierls**. By now, everyone was talking about minimal durations (somehow derived from or correlated to the mass or some other property of each type of elementary particle), not about time “atoms” or a lattice. This subtle conceptual transition between mutually-contradictory notions caused an almighty and enduring confusion. Is time itself somehow discrete/quantized/atomized – or are our measurements discontinuous?

Ever since the early 1960s and especially during the 1990s, there have been several attempts to build on the work of the likes of **H. S. Snyder** (Physical Review 71, (1) 1947, 38) to suggest a quantized spacetime or a Quantum Field Theory, **Tsung Dao Lee’s** work being the most notable attempt. More recent work with relativistic stochastic models led inexorably to discrete time

P. Caldirola postulated the existence of a chronon (1955, 1980): ***“An elementary interval of time characterizing the variation of the particle’s state under the action of external forces”.*** He calculated chronons for several types of particles, most notably the electron, both classical and in (nonrelativistic) quantum mechanics.

In 1982-3, **Sam Vaknin** proposed that chronons may be actual particles – more about Vaknin's work HERE. A decade later, in 1992, **Kenneth J. Hsu** suggested the very same thing (though without reference to Vaknin's work). He postulated sequencing cues delivered to particles by captured chronons. Like Vaknin, he hypothesized the existence of various types of chronons ("large" and small). Chronons, wrote Hsu are also involved in the catalysis of events. Finally, like Vaknin, Hsu also posited a field theory for the flow of chronons. In 1994, **C. Wolf** again suggested the existence of time atoms (Nuov. Cim. B 109 (3) 1994 213).

In 1993, **Arthur Charlesby** suggested that particles have an intrinsic discrete time property and that time (interval in the presence of relative motion) has a "quantized nature". This dispenses with the need for a wave concept as a mere mathematical expedient in the case of individual events (though still useful in contemplating continuous relative motion). This notion of "proprietary" or "individual" system-specific time as distinct from a "systemic", overall Time was further explored by **Alexander R. Karimov** in 2008.

In the same year (1993), **Sidney Golden** published a paper in which he claimed that ***"quantum time-lapses are ... an essential feature of the changes undergone by the energy-eigenfunction-evaluated matrix elements of statistical operators that evolve in accordance with an intrinsic temporal discreteness characteristic of strictly irreversible behavior."***

A year later, in 1994, **A. P. Balachandran** and **L. Chandar** studied the quantized of time in discretized gravity models with multiple-valued Hamiltonians. **Ruy H. A. Farias** and **Erasmo Recami** (2010) applied a quantum of time to obtain startlingly impressive consequences regarding the treatment of electrons (and, more generally, leptons), the free particle, the harmonic oscillator, and the hydrogen atom in both classical and quantum physics, in effect proffering a discretized and surprisingly powerful and useful quantum mechanics. Strangely, their work had very little resonance.

Quantized time has been used to suggest solutions to a panoply of riddles in physics, including the K-meson decay, the Klein-Gordon equation, and the application of Kerr-Newman black holes to electron theory, q-deformations and stochastic subordination ("quantum subordination"), among others (**R. Hakim**, Journal of Mathematical Physics 9 1968, 1805; **B. G. Sidharth**, 2000, **Alexander R. Karimov**,2008; **Claudio Albanese and Stephan Lawi**).

Sam Vaknin's Work

In his doctoral dissertation (Ph.D. Thesis available from the Library of Congress), Vaknin postulates the existence of a particle (chronon). Time is the result of the interaction of chronons, very much as other forces in nature are "transferred" in such interactions.

The Chronon is a time "atom" (actually, an elementary particle, a time "quark"). We can postulate the existence of various time quarks (up, down, colors, etc.) whose properties cancel each other (in pairs, etc.) and thus derive the time arrow (time asymmetry).

Vaknin's postulated particle (chronon) is not only an ideal clock, but also mediates time itself (same like the relationship between the Higgs boson and mass.) In other words: I propose that what we call "time" is the interaction between chronons in a field. The field ***is*** time itself. Chronons exchange a particle and thereby exert a force which we call time. Introducing time as a fifth force gives rise to a quasi-deterministic rendition of quantum theories and links inextricably time to other particle properties, such as mass.

"Events" are perturbations in the Time Field and they are distinct from chronon interactions. Chronon interactions (i.e. particle exchange) in the Time Field generate "time" (small t) and "time asymmetry" as we observe them.

Vaknin's work is, therefore, a Field Theory of Time.

Future directions of research in Sam Vaknin's Work

Timespace can be regarded as a wave function with observer-mediated collapse. All the chronons are entangled at the exact "moment" of the Big Bang. This yields a relativistic QFT with chronons as its Field Quanta (excited states.) The integration is achieved via the quantum superpositions.

Another way to look at it is that the metric expansion of time is implied if time is a fourth dimension of space. Time may even be described as a PHONON of the metric itself.

A more productive approach may involve Perturbative QFT. Time from the Big Bang is mediated by chronons and this leads to expansion (including in the number of chronons.) In this case, there are no bound states.

Chronons as excitation states (stochastic perturbations, vibrations) tie in nicely with superstring theories, but without the baggage of extra dimensions and without the metaphysical nonsense of "music of the spheres". Perturbations also yield General Relativity: cumulative, "emerging" perturbations amount to a distortion (curvature) of time-space. Both superstring theories and GRT are, therefore, private cases of a Chronon Field Theory.

Eytan H. Suchard's Work

Interacting particles with non-gravitational fields can be seen as clocks whose trajectory is not Minkowsky geodesic.

A field in which a small enough clock is not geodesic can be described by a scalar field of time whose gradient has non-zero curvature. The scalar field is either real which describes acceleration of neutral clocks made of charged matter or imaginary, which describes acceleration of clocks made of Majorana type matter.

This way the scalar field adds information to space-time, which is not anticipated by the metric tensor alone. The scalar field can't be realized as a coordinate because it can be measured from a reference sub-manifold along different curves.

In a "Big Bang" manifold, the field is simply an upper limit on measurable time by interacting clocks, backwards from each event to the big bang singularity as a limit only.

In De Sitter / Anti De Sitter space-time, reference sub-manifolds from which such time is measured along integral curves are described as all the events in which the scalar field is zero. The solution need not be unique but the representation of the acceleration field by an anti-symmetric matrix is unique up to SU(2) x U(1) degrees of freedom.

Matter in Einstein-Grossmann equation is replaced by the action of the acceleration field, i.e. by a geometric action which is not anticipated by the metric alone. This idea leads to a new formalism of matter that replaces the conventional stress-energy-momentum-tensor. The formalism will be mainly developed for classical but also for quantum physics. The result is that a positive charge manifests small attracting gravity and a stronger but small repelling acceleration field that repels even uncharged particles that measure proper time, i.e. have rest mass.

The negative charge manifests a repelling anti-gravity but also a stronger acceleration field that attracts even uncharged particles that measure proper time, i.e. have rest mass.

The theory leads to causal sets. Spacetime exists only where a chronon wave-function collapses. Work still to be done is to replace particles by strings of collapse events. The theory in its quantum form is of events and not of particles.

The theory has technological repercussions and implications regarding "Dark Matter" and "Dark Energy".

Online Bibliography

Read **"Electro-gravity via geometric chrononfield"** by **Eytan H. Suchard** (Journal of Physics: Conference Series, Volume 845, conference 1), presented at the 10th Biennial Conference on Classical and Quantum Relativistic Dynamics of Particles and Fields, 6–9 June 2016, Ljubljana, Slovenia (**PDF version**) (**Updated ArXiv**)

Read "**Upper Time Limit, Its Gradient Curvature, and Matter**" **by Eytan H. Suchard** (Journal of Modern Physics and Applications 2014, 2014:5)

Read **"Absolute Maximum Proper Time to an Initial Event, the Curvature of Its Gradient along Conflict Strings and Matter" by Eytan H. Suchard** (Journal of Modern Physics Vol.4 No.6 (2013), Article ID:33086)

Read the original paper **"Upper Time Limit, Its Gradient Curvature, and Matter" by Eytan H. Suchard** and a corrected, **updated version** (or **HERE** or **HERE**)

Read "**Electro-gravitational Technology via Chronon Field" by Eytan H. Suchard** (Physical Science International Journal, Vol. 4 Issue 8 (2014) – **Abstract** – **Supplementary Files** - **DOI**

Read "**Electro-gravity via Geometric Chronon Field**" by Eytan H. Suchard (Physical Science International Journal, Vol. 7 Issue 3 (2015) pp152-185 - **Abstract**

Chronons (Wikipedia) and HERE

Chronons (in Science Fiction)

Historical Bibliography of Chronons and Quantized Time

Chapter 2 – Introduction of a Quantum of Time ("chronon"), and its Consequences for the Electron in Quantum and Classical Physics - Ruy H.A. Farias, Erasmo Recami -

doi:10.1016/S1076-5670(10)63002-9 - Advances in Imaging and Electron Physics - Volume 163, 2010, Pages 33–115 - Published by Elsevier

From time atoms to space-time quantization: the idea of discrete time, ca 1925–1936 - Helge Kragh, Bruno Carazza - doi:10.1016/0039-3681(94)90061-2 - Studies in History and Philosophy of Science Part A - Volume 25, Issue 3, June 1994, Pages 437–462 - Published by Elsevier

The chaotic universe - B.G. Sidharth - doi:10.1016/S0960-0779(98)00332-4 - Chaos, Solitons & Fractals - Volume 11, Issue 8, June 2000, Pages 1171–1174 - Published by Elsevier

Quantized space-time and time's arrow - B.G. Sidharth - doi:10.1016/S0960-0779(98)00331-2 - Chaos, Solitons & Fractals - Volume 11, Issue 7, 1 June 2000, Pages 1045–1046 - Published by Elsevier

The quantum dimension of space-time - Enrique Alvarez, Juli Cespedes, Enric Verdaguer - doi:10.1016/0960-0779(94)90054-X - - Chaos, Solitons & Fractals - Volume 4, Issue 3, March 1994, Pages 411–414 - Published by Elsevier

Discrete time from quantum physics - A.P. Balachandran, L. Chandar - doi:10.1016/0550-3213(94)90207-0 - Nuclear Physics B - Volume 428, Issues 1–2, 10 October 1994, Pages 435-448 - Published by Elsevier

Quantization of time: an implication of strictly-irreversible evolution of dynamically isolated quantum systems - Sidney Golden - doi:10.1016/0378-4371(94)90534-7 - Physica A: Statistical Mechanics and its Applications - Volume 208, Issue 1, 1 July 1994, Pages 65-90 - Published by Elsevier

Radiation: Waves or particles? A quantized approach to time - Arthur Charlesby - doi:10.1016/0969-806X(93)90416-R - Radiation Physics and Chemistry - Volume 42, Issues 4–6, October–December 1993, Pages 977–984 - Published by Elsevier - https://www.elsevier.com/

Waves and particles—quantisation of the interval between eventss0 - Arthur Charlesby - doi:10.1016/0969-806X(94)00085-9 - Radiation Physics and Chemistry - Volume 45, Issue 2, February 1995, Pages 175–186 - Published by Elsevier

The Snyder space-time quantization, q-deformations, and ultraviolet divergences - R.M. Mir-Kasimov - doi:10.1016/0370-2693(96)00408-X - Physics Letters B - Volume 378, Issues 1–4, 20 June 1996, Pages 181–186 - Published by Elsevier

Chronon Corrections to the Dirac Equations - Andrei A. Galiautdinov and David R. Finkelstein - ArXiv, June 17, 2018

Other Bibliography

Lévi, Robert (1927) - **Théorie de l'action universelle et discontinue** - Journal de Physique et le Radium 8 (4): 182–198

Margenau, Henry - **The Nature of Physical Reality** - McGraw-Hill, 1950

Volume 04 Issue 01-March, 2018

Yang, C. N. - **On quantized space-time** - Physical Review 72 (9): 874

Caldirola, P. - **The introduction of the chronon in the electron theory and a charged lepton mass formula** - Lett. Nuovo Cim. 27 (8): 225–228

Albanese, Claudio; Lawi, Stephan - **Time Quantization and q-deformations** - Journal of Physics A. 37 (8): 2983–2987

Hsu, Kenneth J. - **In search of a Physical Theory of Time** - Proceedings of the National Academy of Sciences of the United States of America - 01 November 1992, Vol.89(21), pp.10222-10226

Hsu, Kenneth J. - **Are Chronons the Elementary Particles in space and Time?** - Terrestrial, Atmospheric, and Oceanic Sciences