Physics needs only Clocks, Time can be abandoned

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Abstract

Numerical order $t_0, t_1, t_2 ....t_n$ of a physical event we measure with a clock. A sequence t_{n-1} is "before" sequence t_n equivalently to natural number $n-1$ is before natural number n. Numerical order $t_0, t_1, t_2 ....t_n$ of a physical event has no duration. It runs in a timeless space where physical time is run of clocks. Velocity v of a physical event is derived from its numerical order $t_0, t_1, t_2 ....t_n$.

Key words: time, space, space-time, run of clocks, velocity, numerical order, duration, psychological time

Introduction

In space "before" and "after" exist only as a numerical order $t_0, t_1, t_2 ....t_n$ of a physical event: t_{n-1} is "before" t_n equivalently to natural number $n-1$ is "before" natural number n. Numerical order of physical event we measure with "ticking" of a clock. t_0 represents beginning of the measurement, t_n end of the measurement. Velocity v of a physical event is derived from its numerical order t_n: $v = \frac{d}{t_n} ms^{-1}$. Frequency γ of a physical event is derived from its numerical order t_n: $\gamma = \frac{1}{t_n} s^{-1}$.

Fundamental unit of numerical order of physical events Planck time $t_p = 5{,}39124 * 10^{-44} s$ is derived from the light speed: $t_p = \frac{c}{l_p}$ where l_p is a Planck distance. Planck time t_p exists in the universe as a fundamental physical unit that governs numerical order physical events. Immediate physical events as Einstein-Podolski-Rosen and some others have numerical order zero: $t_n = 0$ (1).

In original solution gravity is an immediate physical event with zero velocity

In original papers on General Theory of Relativity curvature of space is a direct medium that generates gravitational motion of material objects into direction of higher curvature of space. There is no direct attraction force between material objects. Material object causes curvature of space and curvature of space causes gravitational motion. Gravitational interaction $mass \leftrightarrow space \leftrightarrow mass$ is immediate: presence of mass increases curvature of space that causes gravitational motion. Mass acts on other mass indirectly via curvature of space: $mass \leftrightarrow curvature \leftrightarrow mass$. Curvature of space is defined with Einstein curvature tensor: $G\mu\nu = \frac{8\pi G}{c^4} * T\mu\nu$ which becomes in geometrized units $G\mu\nu = 8\pi T\mu\nu$.

In original papers from 1916 Einstein did not mention gravitational waves. This idea arises few months later. Einstein introduces gravitational waves as space-time perturbations (2). With introduction of gravitational waves that propagate with a light speed gravity is interpreted as physical phenomena with $t_n \triangleright 0$ and $v \triangleright 0$.

Timeless description of physical events

Some of researchers are challenged with the view that space-time is the fundamental arena of the universe. They point out that the mathematical model of space-time does not correspond to physical reality, and propose a "state space" or a "timeless space" as the fundamental arena where time exists as run of clocks.

For example, in *A New Geometric Framework for the Foundations of Quantum Theory and the Role Played by Gravity*, Palmer underlines that, since quantum theory is inherently blind to the existence of state-space geometries, attempts to formulate unified theories of physics within a conventional quantum-theoretic framework are misguided, and that a successful quantum theory of gravity should unify the causal non-Euclidean geometry of space-time with the a-temporal fractal geometry of state space (3). In this paper, Palmer introduces a new geometric law of physics about the nature of physical reality based on an Invariant Set Postulate. The Invariant Set Postulate conjectures that states of physical reality are defined by a fractal geometry *I* , embedded in state space and invariant under the action of some subordinate causal dynamics D_I. The postulate is motivated by two concepts that would not have been known to the founding fathers of quantum theory: the generic existence of invariant fractal subsets of state space for certain nonlinear dynamical systems, and the notion that the irreversible laws of thermodynamics are fundamental rather than phenomenological in describing the physics of extreme gravitational systems. The Invariant Set Postulate posits the existence of a fractionally-dimensioned subset *I* of the state space of the physical world (namely the universe as a whole). *I* is an invariant set for some presumed-causal (namely relativistic) deterministic dynamical system D_I ; points on *I*, called also "world states", remain on *I* under the action of D_I. World states of physical reality are those, and only those, lying precisely on *I*. It is important to underline that in Palmer's theory, the subset *I* of the state space is more primitive than the deterministic dynamical system D_I. Given *I*, $D_I(t)$ maps some point $p \in I$, a parameter distance *t* along a trajectory of *I*. Crucially, D_I is undefined at points $\notin I$: if states of physical reality necessarily lie on *I*, then points $p \notin I$ in state space are to be considered literally "unreal". For practically-relevant theories (such as quantum theory) the intricate structure of *I* is unknown and these points of unreality cannot be ignored. As regards the key question of how to represent quantum-theoretic states in a mathematically-consistent way for such points of unreality, the Invariant Set Postulate provides support to the search for a timeless description of physics: by treating the geometry of the invariant set as primitive introduces a fundamentally timeless perspective into the formulation of basic physics.

Clocks as a measuring system of numerical order $t_0, t_1, t_2 \ldots\ldots t_n$ can be considered the most direct and natural development of Palmer's approach: it is a description of motion in physics where velocity v of a physical event is derived from its numerical order t_n : $v = \frac{d}{t_n} ms^{-1}$.

Numerical order of change $t_0, t_1, t_2 .... t_n$ runs in timeless space

Girelli, Liberati and Sindoni have recently developed a toy model in which they have showed how the Lorentzian signature and a dynamical space-time can emerge from a non-dynamical Euclidean space, with no diffeomorphisms invariance built in. In this sense this toy-model provides an example where time (from the geometric perspective) is not fundamental, but simply an emerging feature (4). In more detail, this model suggests that at the basis of the arena of the universe there is some type of “condensation", so that the condensate is described by a manifold R^4 equipped with the Euclidean metric $\delta^{\mu\nu}$. Both the condensate and the fundamental theory are timeless. The condensate is characterized by a set of scalar fields $\Psi_i(x_\mu)$, i=1,2,3. Their emerging Lagrangian L is invariant under the Euclidean Poincarè group ISO(4) and has thus the general shape

L = F(X1;X2;X3) = f(X1) + f(X2) + f(X3); $X_i = \delta^{\mu\nu}\partial_\mu \Psi_i \partial_\nu \Psi_i$ (1).

The equations of motion for the fields $\Psi_i(x_\mu)$ are simply given by

$$\partial_\mu\left(\frac{\partial F}{\partial X_i}\partial^\mu \Psi_i\right) = 0 = \sum_j\left(\frac{\partial^2 F}{\partial X_i \partial X_j}\left(\partial^\mu X_j\right) + \frac{\partial F}{\partial X_i}\partial_\mu \partial^\mu \Psi_i\right) \quad (2)$$

The fields $\Psi_i(x_\mu)$ can be expressed as $\Psi_i = \psi_i + \varphi_i$ where φ_i are the perturbations around the solutions ψ_i of the above equation. The lagrangian for ψ_i is given by

$$F\left(\overline{X}_1, \overline{X}_2, \overline{X}_3\right) + \sum_j \frac{\partial F}{\partial X_j}\left(\overline{X}\right)\delta X_j + \frac{1}{2}\sum_{jk}\frac{\partial^2 F}{\partial X_j \partial X_k}\left(\overline{X}\right)\delta X_j \delta X_k + \frac{1}{6}\sum_{jkl}\frac{\partial^3 F}{\partial X_j \partial X_k \partial X_l}\left(\overline{X}\right)\delta X_j \delta X_k \delta X_l$$

(3)

where $\overline{X}_i = \delta^{\mu\nu}\partial_\mu \psi_i \partial_\nu \psi_i$ and $\delta X_i = 2\delta_\mu \psi_i \partial^\mu \psi_i \partial_\mu \varphi_i \partial^\mu \varphi_i$.

Different choices of the solutions ψ_i lead to different metrics

$$g_k^{\mu\nu} = \frac{df}{dX_k}\left(\overline{X}_k\right)\delta^{\mu\nu} + \frac{1}{2}\frac{d^2 f}{\left(dX_k\right)^2}\left(X_k\right)\partial^\mu \psi_k \partial^\nu \psi_k \quad (4).$$

If one considers the specific class of equations of motion for which $\psi_i = \alpha^\mu x_\mu + \beta$, the SO(4) symmetry leads to $\overline{\psi} = \alpha x_0 + \beta$ which shows that the choice of the coordinate is completely arbitrary. Hence the Lorentzian signature can be obtained for the condition $\frac{df}{dX}(\overline{X}) + \frac{\alpha^2}{2}\frac{d^2 f}{(dX)^2}(\overline{X}) < 0$, $\frac{df}{dX}(\overline{X}) > 0$ and in this case the lagrangian becomes $L_{eff} = \sum_i \eta^{\mu\nu}\partial_\mu \varphi_i \partial_\nu \varphi_i$ where $\eta^{\mu\nu}$ is the Minkowski metric. Moreover, Girelli, Liberati and Sindoni have showed that by means of the change of variables

$$\begin{pmatrix}\varphi_1 \\ \varphi_2 \\ \varphi_3\end{pmatrix} = \Phi \begin{pmatrix}\phi_1 \\ \phi_2 \\ \phi_3\end{pmatrix} \quad (5)$$

with $\Phi^2 = \sum_i \phi_i^2 = l^2$ where *l* is related to Planck scale, a dynamical space-time emerges from L_{eff}, which is characterized by the Einstein-Fokker equations

$R = 2\pi G_N T$ (6),

$C_{\alpha\beta\gamma\delta} = 0$ (7)
where
$R = \frac{6}{l^2}T$ (8),
$T(\phi_i) = g^{\mu\nu}T_{\mu\nu}(\phi_i) = -\Phi^2 \sum_i \eta^{\mu\nu}\partial_\mu\phi_i\partial_\nu\phi_i$ (9),
$g_{\mu\nu} = \Phi^2(x)\eta_{\mu\nu}$ (10)
(which shows that the gravitational degree of freedom is encoded in the scalar field Φ) and where G_N is proportional to l^{-2}.

The toy model developed by Girelli, Liberati and Sindoni shows in a clear way that time cannot be considered a fundamental reality, at a fundamental level space is timeless: the picture of the universe provided by this model is a mathematical proof of the idea that numerical order of change runs in a timeless space.

Numerical order experienced through psychological time creates a sensation of duration

Recent neurological research shows by measuring a physical event with a clock we experience numerical order $t_0, t_1, t_2.......t_n$ of event through psychological time "past-present-future". However numerical order of physical event runs in timeless space and has no duration.

"Traditionally, the way in which time is perceived, represented and estimated has been explained using a pacemaker–accumulator model that is not only straightforward, but also surprisingly powerful in explaining behavioural and biological data. However, recent advances have challenged this traditional view. It is now proposed that the brain represents time in a distributed manner and tells the time by detecting the coincidental activation of different neural populations (5).

Conclusions

Planck time t_p exists in the universe as a fundamental physical unit that governs numerical order $t_0, t_1, t_2.......t_n$ of material change i.e. motion running in a timeless universe. Numerical order of physical events we measure with clocks. Velocity v of a physical event is derived from its numerical order.

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