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The mathematics of the grand unified theory

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ABSTRACT

This paper surveys the mathematics of GUT and highlights the author's new real number system $\mathbf{R}^*$ which is a continuum, non-Archimedean and non-Hausdorff, but its subspace of decimals is countably infinite, discrete, Archimedean and Hausdorff. The paper also proves Goldbach's conjecture in $\mathbf{R}^*$ and provides an overview of GUT and qualitative and computational models of many of the presently ill-defined physical concepts, e.g., gravity.

We run through the mathematics of the Grand Unified Theory (GUT) which is much broader than that which Albert Einstein envisioned — to unify the forces and interactions of physics. It unifies the forces and interactions of nature and, therefore, covers all natural sciences. Consequently, the mathematics of GUT is the mathematics of the natural sciences which is practically all of mathematics but we shall only mention those directly involved in its development. However, we highlight the new real number system, as it qualitatively and computationally models many ill-defined physical concepts of current physics, such as the superstring (basic constituent of matter), gravity, black hole, our finite universe and the timeless and boundless Universe.

1. Classical mathematics

1.1. Generalized curves and surfaces

L.C. Young developed generalized curves (GC) and surfaces for the calculus of variations and optimal control theory [27,30]. A generalized curve has a set-valued derivative (e.g., rapid oscillation [5,11]); a generalized surface has a set-valued jacobian [30]. GC computationally models the superstring, cosmic wave and path of elementary particle [15,31].

1.2. The primum and photon

In cylindrical coordinates the primum has the equation $x = t, y(t) = \beta(\sin n\pi t)(\cos^m k\pi t), \theta = n\pi t, t \in [-1/k, 1/k]$, n, m, k, integers, $n \gg k$, m even. Cycle energy: Planck's constant $h = 6.64 \times 10^{-34}$ J. Scooped up and carried by cosmic

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wave, its cycles flatten to rapid oscillation, $z = 0, x = t, y(t) = \beta(\sin n\pi t)(\cos^m k\pi t)$ due to dark viscosity. It becomes photon, $z = 0, y(t) = \beta(\sin n\pi t)(\cos^m k\pi t)$, when it breaks off from loop; energy of one full cycle of the primum or one full arc of photon is h; toroidal flux speed: 7×10^{22} cm/s [2].

1.3. Hubble's law

One of the stunning discoveries of the last century that still haunts relativists today was the staggering rate of expansion and acceleration of our universe [26]. Based on extensive direct measurement of the separation of galaxies from Earth, Edwin Hubble formulated his law that expresses the rate of separation of a galaxy from us at distance s from Earth:

$$\mathrm{d}s/\mathrm{d}t = \rho s, \tag{1}$$

where $\rho = 1.7 \times 10^{-2}$/km distance of the receding galaxy from Earth. For convenience, we measure distance S along a great circle in the spherical dark halo of our universe. Then,

$$\mathrm{d}S/\mathrm{d}t = \rho S. \tag{2}$$

Since this discovery, the estimate of the age of our universe increased from the original 8 billion years to the present 14.7 billion years and there is talk of raising it to 20 billion. Each time an older star is discovered the estimate is adjusted to accommodate it. This star-chasing game is based on the incorrect premise that only our universe exists. In fact, there are others, and the evidence is quite strong. One piece of evidence is the presence of galaxy clusters traversing our universe [24] and another is the collision of galaxies coming from different directions [25]. Galaxies in our universe travel along outward radial trajectories and cannot collide among themselves. Yet another piece of evidence is the discovery of stars in the Milky Way older than the Big Bang [24].

Therefore, we stick to the original estimate of 8 billion years to solve (2) and find the radius r as a function of t. Since $\mathrm{d}S/\mathrm{d}t = 2\pi\,\mathrm{d}r/\mathrm{d}t$ and (2) is independent of the distance between us, and the other galaxy it holds when $S = r$. Then,

$$2\pi\,\mathrm{d}r/\mathrm{d}t = \rho r \quad \text{or} \quad \mathrm{d}r/r = (\rho/2\pi)\mathrm{d}t. \tag{3}$$

Solving r, reckoning time from the Big Bang and taking light year and 1 billion years as units,

$$r(t) = 10^{10}\mathrm{e}^{(\rho/2\pi)(t-8)} \text{ light years}, \qquad r'(t) = (\rho/2\pi)10^{10}\mathrm{e}^{\rho/2\pi(t-8)} \text{ light years/billion year},$$
$$r''(t) = (\rho/2\pi)^2 10^{10}\mathrm{e}^{\rho/2\pi(t-8)} \text{ light years /(billion year)}^2. \tag{4}$$

Using standard units we have, at $t = 8$,

$$r(8) = 3.2 \times 10^{22}\ \text{km}, \qquad r'(8) = 840\ \text{km/s}, \qquad r''(8) = 1.7 \times 10^{-2}\ \text{km/s}. \tag{5}$$

Since $r'' > 0$, our universe is in the young phase of its cycle, with its power of spin still rising. This acceleration is considerable and if it continues, the speed of the outward radial flight of the galaxies will surpass the speed of light soon. The value of ρ is based on direct observation and analysis of the Doppler effect on the spectrum of light coming from a receding source. Now, Encarta Premium has this figure: $\rho = 260{,}000$ km/h/3.3 million light years, i.e., the receding galaxy is moving away from Earth faster by 260,000 km/h for every 3.3 million light year's distance away from us. Does it make sense?

Converting to standard units and simplifying we get $\rho = 3 \times 10^{-19}$/km; inserting this value in (3) we obtain, $r'(t) = 5 \times 10^{-14}$ km/s, the supposed rate of radial expansion of our universe and acceleration of 3×10^{-32} km/s. This points to a static universe that does not match present observation and measurement [24]. Moreover, if this figure were correct, we would have been roasted by intense heat due to the steady formation of stars in the Cosmos, one per minute [1, 27], and the emergence of two baby galaxies discovered since 2004. On the contrary; the average temperature of the Cosmos remains steady at 4 °C.

1.4. The integrated Pontrjagin maximum principle

Young's integrated Pontrjagin maximum principle [28] provides the computational solution of the gravitational n-body problem [6]; it says:

Let G be a convex family of functions $g(t, x)$, g measurable in t, continuous in x, $x \in \mathbf{R}^n$; let $\hat{h}$ be a corresponding Hamiltonian function $yg(t, x)$; $C : x(t), t_1 \le t \le t_2$ and M-extremal satisfying, a.e., corresponding to the differential equation, $\mathrm{d}x/\mathrm{d}t = \partial\hat{h}/\partial y$, subject to conditions in [31]; then there exists a conjugate vector $y(t)$ along C with the pair $(x(t), y(t))$ satisfying.

(a) The canonical Euler equations: $\mathrm{d}x/\mathrm{d}t = \partial\hat{h}/\partial y$, $\mathrm{d}y/\mathrm{d}t = -\partial\hat{h}/\partial x$;
(b) The Weierstrass condition: as a function of $h \in H$, the integral $\int h(t, x(t), y(t))\mathrm{d}t$, from t_1 to t_2, attains its minimum when $h = \hat{h}$;
(c) The transversality condition: the transversality vector $(-\eta(t_1), \eta(t_2))$ is inward normal at the boundary of the smooth manifold M, the target.

This principle provides the computation of the trajectories and positions of the n bodies at a later time [6]. The qualitative solution is provided by GUT.