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CROSSING SYMMETRY IS INCOMPATIBLE WITH GENERAL RELATIVITY*

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Consider a proton moving in empty space past a positively charged earth with charge (squared) $Q_E^2 = Gm_pM_E$. In the absence of further information, we expect it to move past the earth without being deflected. The CPT theorem asserts that an anti-proton must move past a negatively charged anti-earth in precisely the same way, so gives us no new information. Conventional theories predict that an anti-proton moving past a positively charged earth at distance r would experience an acceleration toward the earth of twice the amount $Gm_pM_E/r^2 = Q_E^2/r^2$ that a neutral object of mass m_p would experience. However, if we are correct in asserting that "crossing symmetry" requires *all* "forces" (i.e. accelerations per unit inertial mass) on a particle to reverse when that particle is replaced by its anti-particle, then the fact that we can use electromagnetic forces to balance a particle in a gravitational field plus crossing symmetry *predict* that the electromagnetic fields would have to be reversed in order to balance an anti-particle in the same configuration.

Our argument from "crossing symmetry" is unconventional in that we use the observable phenomenon of "acceleration per unit mass", or in relativistic S-matrix theory the change in the space-components of 4-velocity, in our definition. The conventional second-quantized relativistic field theory starts, instead, from an interaction Lagrangian expressed in terms of a "gauge potential" which is not observable. Such theories are not problem-free in the Newtonian and Coulombic limits. To quote Weinberg[1]

"The most general covariant fields .... cannot represent real photon and graviton interactions because they give amplitudes for emission and absorption of massless particles [of spin j] which vanish as p^j for momentum $p \to 0$."

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One is permitted to question whether the "gauge invariant" prescription which Weinberg uses to meet this problem is mathematically well defined in a class of theories which (a) do not have a well defined "correspondence limit" in either non-relativistic quantum mechanics or the classical, relativistic (Maxwell and Einstein) field theories of electromagnetism and gravitation, (b) necessarily give, as Oppenheimer put it, "nonsensical [i.e. infinite] answers to sensible questions", and (c) have not reached consensus on how to formulate "quantum gravity",

In contrast, our finite and discrete reconciliation between quantum mechanics and relativity meets problem (a) by deriving the Maxwell and Einstein fields from scale-invariant measurement accuracy bounded from below in a manner reminiscent of Bohr and Rosenfeld's analysis of the measurability of electric and magnetic fields.[2] We have claimed[3] that this analysis removes the physical "paradox" in the Feynman 1948 derivation reported by Dyson[4] and extended to gravitation by Tanimura.[5] We also claim that a significant extension of the calculus of finite differences to an ordered (non-commutative) formalism provides a rigorous mathematical context for the derivation.[6] Our finite particle number S-matrix theory conserves (relativistic) 3-momentum at 3-vertices, but is off energy shell by a finite amount. Our finite and discrete kinematics satisfies discrete conservation laws for physically realizable multi-leg diagrams; it fits comfortably into the practice of high energy elementary particle physics. Because our theory is finite and discrete, and hence can identify c as the maximum velocity at which information can be transferred between distinct locations, problem (b) never arises. As to problem (c), gravitation and electromagnetism are reconciled at the bound state level by a common treatment of both which is formally equivalent to the Bohr's relativistic calculation of the energy levels of the hydrogen atom, using combinatorially calculated coupling constants; the method can be extended to yield the Sommerfeld formula for the fine structure of hydrogen[7] and its gravitational equivalent. The classic tests of GR are met, and we believe that the time tests of the pulsar data can be met as well. The quantum number structure predicts the observed particles of the standard model of quarks and leptons, and yields no unobserved particles. Given $\hbar, c$ and m_p as empirical input, we compute $G, G_F, e^2, m_p/m_e, m_\pi/m_e, m_\mu/m_e$ to an accuracy of a part in $\approx 10^4 - 10^7$, leaving enough room for improvement to make the theory interesting to pursue, or to produce a crucial conflict with experiment. Results are given in the table.

As we explain in the first paragraph, the most dramatic prediction of our theory to date, which is currently under direct experimental scrutiny at the CERN Low Energy Anti-proton Ring, and can be tested by still more sensitive techniques,[8] is that

ANTI-MATTER "FALLS" UP.

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Table. **Coupling constants and mass ratios** predicted by the finite and discrete unification of quantum mechanics and relativity. Empirical Input: $c, \hbar$ and m_p as understood in the "Review of Particle Properties", Particle Data Group, *Physics Letters*, **B 239**, 12 April 1990.

COUPLING CONSTANTS

Coupling Constant	Calculated	Observed
$G^{-1}\frac{\hbar c}{m_p^2}$	$[2^{127}+136]\times[1-\frac{1}{3\cdot 7\cdot 10}] = 1.693\ 31\ldots\times 10^{38}$	$[1.69358(21)\times 10^{38}]$
$G_F m_p^2/\hbar c$	$[256^2\sqrt{2}]^{-1}\times[1-\frac{1}{3\cdot 7}] = 1.02\ 758\ldots\times 10^{-5}$	$[1.02\ 682(2)\times 10^{-5}]$
$sin^2\theta_{Weak}$	$0.25[1-\frac{1}{3\cdot 7}]^2 = 0.2267\ldots$	$[0.2259(46)]$
$\alpha^{-1}(m_e)$	$137\times[1-\frac{1}{30\times 127}]^{-1} = 137.0359\ 674\ldots$	$[137.0359\ 895(61)]$
$G^2_{\pi N\bar{N}}$	$[(\frac{2M_N}{m_\pi})^2-1]^{\frac{1}{2}} = [195]^{\frac{1}{2}} = 13.96..$	$[13, 3(3), > 13.9?]$

MASS RATIOS

Mass ratio	Calculated	Observed
m_p/m_e	$\frac{137\pi}{\frac{3}{14}\left(1+\frac{2}{7}+\frac{4}{49}\right)\frac{4}{5}} = 1836.15\ 1497\ldots$	$[1836.15\ 2701(37)]$
$m_\pi^\pm/m_e$	$275[1-\frac{2}{2\cdot 3\cdot 7\cdot 7}] = 273.12\ 92\ldots$	$[273.12\ 67(4)]$
m_{π^0}/m_e	$274[1-\frac{3}{2\cdot 3\cdot 7\cdot 2}] = 264.2\ 143\ldots$	$[264.1\ 373(6)]$
m_μ/m_e	$3\cdot 7\cdot 10[1-\frac{3}{3\cdot 7\cdot 10}] = 207$	$[206.768\ 26(13)]$

COSMOLOGICAL PARAMETERS

Parameter	Calculated	Observed
N_B/N_γ	$\frac{1}{256^4} = 2.328....\times 10^{-10}$	$\approx 2\times 10^{-10}$
M_{dark}/M_{vis}	≈ 12.7	$M_{dark} > 10M_{vis}$
$N_B - N_{\bar{B}}$	$(2^{127}+136)^2 = 2.89...\times 10^{78}$	*compatible*
$\rho_/\rho_{crit}$	$\approx \frac{4\times 10^{79} m_p}{M_{crit}}$	$.05 < \rho_/\rho_{crit} < 4$