Poincaré's Geometric Conventionalism and Relativity Principle: a physical perspective on GRT

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Abstract

Since Einstein's 1916 development of gravitation it is considered a necessity that a theoretically consistent and experimentally accurate theory of gravitation requires the intrinsic curvature of Riemannian geometry [1, 2]: concomitantly the ontology of space and time becomes entangled with gravitation, and 'reality', as the observer invariant present, is obliterated. Standard geometrodynamic relativity theory thus poses a number of interpretative issues and ontological ruptures. In precursor approaches to gravitation [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19] ontologically distinct elements of the physical interpretation of 'relativity' theory and 'ether' theory were included: kinematical affectation of measurement devices, unobserved 'preferred' frame movement, gravitational potential, etc.. The historical Lorentz-Poincaré interpretation with physical Lorentz-Fitzgerald 'rod'-contraction and 'clock'-slowing, and light synchronization between observers, implied kinematical effects on space and time *congruence standards* (e.g. [20, 21]). The introduction of gravitation itself in the physical congruence standard, advanced by Poincaré in his 'conventionality' of geometry approach [22, 23, 24, 25], was however effectively superseded by the geometrization of gravitation [26]. The ontology of space and time hinges on the adopted physical congruence standard, as each effective 'alternative metrization' could lead to distinct interpretation and nature of these concepts (e.g. [27, 28]).

Is a Lorentz-Poincaré type program, sustained by geometric 'conventionalism' and modern classical field theory, effectively feasible for General Relativity? *I.e.*, the development of a physical, contrary to geometric, gravitation model i) empirically equivalent with General Relativity Theory (GRT), ii) with distinct gravitational dynamics and physical congruence?

The gravitation model of massless spin-2 field in Minkowski background metric [29, 30, 31] effectively provides alternative metrization (i) although not an explicit interpretation of physical geometry (ii). In order to clearly distinguish gravitational dynamics with *empiric equivalence* to GRT, and *physical congruence* standard, an elementary scalar gravitation model is outlined [32, 33, 34, 35, 36, 37, 38]. The physical *congruence standard* in this model is represented by an isotropic scaling function $\Phi(\mathbf{r})$ which represents the gravitational affectation at position $\mathbf{r}$, as the ratio of a space interval observed by the gravitationally unaffected S_0 and the same infinitesimal interval as observed by gravitationally affected observer S', both at $\mathbf{r}$:

$$d\mathbf{x} = d\mathbf{x}'\Phi(\mathbf{r}) \ (\textit{contraction}) \quad , \quad dt = \frac{dt'}{\Phi(\mathbf{r})} \ (\textit{dilation}) \tag{1}$$

where the inverse scaling effect is set on the relation of affected and unaffected infinitesimal time intervals. Relative to observer S', the invariance of the locally observed velocity of light c', is satisfied by allowing specific spatial variability in the unaffected perspective of observer S_0 (*i.e.* $c(\mathbf{r}) = c'\Phi(\mathbf{r})^2$). The congruence standard (1) leads to gravitationally modified Lorentz transformations (GMLT) [35, 36], formally related to Abraham's and Einstein's early development of gravitation in special relativity [10]-[17], [6]-[9], but essentially different in their effect of scaling relation between affected and unaffected observers. The GMLT between affected locally coincident observers do reduce to regular Lorentz transformations, in accordance with the requirement of local Minkowskian geometry [36].

The *empirical sufficiency* of the model requires the implementation of Poincaré's Principle of Relativity, *i.e.* the unobservability of 'absolute' movement [22, 39, 40, 41]. The Poincaré Principle i) fixes the amplitude of the 'sweep velocity' field of the dynamic source (or the 'vector potential' ζ, [42]), and ii) implies exactly the Post-Newtonian limit of General Relativity [37].

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A critique of the model is made concerning its present scope (coincidence with weak field GRT), and the invalidation of the weak equivalence principle in the affected observer perspective. Some elucidation is done —in terms of the alternatively metrised reference model— of specific geometrized concepts, such as 'frame dragging', 'harmonic coordinate condition', etc.. Finally, the merits of Poincaré's program of 'conventionality of geometry' in gravitation are discussed in relation to the distinct ontological status of space, time and, matter.

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