Abstract

Post-relativistic gravity is a hidden variable theory for general relativity. It introduces the pre-relativistic notions absolute space, absolute time, and ether as hidden variables into general relativity. Evolution is defined by the equations of general relativity and the harmonic coordinate condition interpreted as a physical equation. There are minor differences in predictions compared with general relativity (i.e. trivial topology of the universe is predicted).

The unobservable absolute time is designed to solve the problem of time in quantization of general relativity. Background space and time define a Newtonian frame for the quantization of the gravitational field. By the way, a lot of other conceptual problems of quantization will be solved (i.e. no constraints, no topological foam, no black hole and bib bang singularities, natural vacuum definition for quantum fields on classical background).
1 Introduction

Post-Relativistic Gravity (PG) is a hidden variable theory of General Relativity (GR). The hidden variables are an absolute, *true time* $t$ and an absolute *background space* with affine structure. This space is filled with an *ether* described by the field $g_{ij}(x,t)$. The interaction of the ether with material fields is described by the the Einstein equations

$$R_{ik} - \frac{1}{2} g_{ik} R = \frac{8\pi k}{c^4} T_{ik}$$

and the connection with the hidden variables by the harmonic coordinate equations

$$\Gamma^k = g^{ij} \Gamma^k_{ij} = 0.$$ 

The name **post-relativistic** for the theory seems natural to describe the revival of Newtonian notions in the relativistic context.

PG doesn’t make further assumptions about the internal structure of the ether, nonetheless there are some natural guesses: The ether velocity can be defined by $v^i = g^{i0}/g^{00}$. The space part $g_{ij}(x), i, j = 1, 2, 3$; reminds a deformation tensor. The remaining scalar step of freedom requests an

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interpretation in terms of speed of light. The ether is not stationary, thus one conceptual problem of classical ether theory is solved in PG by unification with gravity.

Considering the interaction of the ether with clocks, which is described by the Einstein equations, we can conclude, as in GR, that the result of clock measurement is proportional to the notion of GR proper time

$$\tau = \int \sqrt{g_{ij}dx^i dx^j}$$

True time $t$ remains not measurable, but is considered to be the more fundamental notion of time which describes past, present, future and causality. GR clock time $\tau$ describes only the distortion of clock measurement caused by gravity. The absence of an appropriate time measurement is considered as a natural property of time we can find in non-relativistic quantum mechanics too [8].

Affine space and time in PG lead to a finite-dimensional symmetry group. Using the Noether theorem we obtain local energy and momentum densities known in GR as the energy-momentum pseudotensor. It’s coordinate-dependence obtains a natural interpretation as the dependence of the hidden steps of freedom, especially the ether velocity.

PG in itself is interesting enough already from pure methodological reasons. It shows that a completely different metaphysical interpretation of our universe including absolute time and an ether is compatible with GR. But the much more interesting point is the essential simplification of quantization.

2 Historical Context

PG was developed by I. Schmelzer [10].

PG can be considered as a generalization of the Lorentz-Poincare version of special relativity [15] to general relativity. It is remarkable that the distinction between two notions of time — true time and time measurement with clocks — has been introduced already by Newton [14].

The harmonic coordinate equation has been often used in GR, starting with Lanczos [12] and Fock [7], up to actual attempts to use them as gauge conditions or clock fields in quantization. But in the context of GR they cause
some problems like different solutions for the same metric and solutions which
don’t cover the whole solution.

Logunov et.al. have introduced the harmonic coordinate equation as a
physical equation into their Relativistic Theory of Gravity [13], [21] and found
the related modification for the black hole and big bang scenario. Different
from PG they have introduced a Minkowski background, and their argumentation
was based on incorrect criticism of GR [17].

The Isham-Kuchar approach [11] interpretes harmonic space and time
coordinates as gravity-coupled massless fields used to identify instants of
time and points in space. This approach remains fully inside standard GR,
a quantization based on this approach faces the same problems as usual GR
quantization. Especially, a “clock field” $t$ will be uncertain and measurable,
different from quantum mechanical time and PG true time.

PG may be described in the classification give by Isham [8] as “GR forced
into a Newtonian framework”. Isham mentions the reduction of the symme-
try group in such an approach we find in PG too. But the reason for rejection
given there — “theoretical physicists tend to want to consider all possible
universes under the umbrella of a single theoretical structure” — is not valid
for PG, because PG describes in their context all possible universes.

3 Comparison With General Relativity

Despite the completely different metaphysics of PG it is de-facto not possible
to distinguish GR and PG by a classical experiment. Nonetheless PG is a
different theory which makes additional predictions compared with GR.

First, topologically nontrivial solutions are obviously forbidden in PG.
Another difference is completeness. A complete PG solutions has to be de-

\[ g_{ij}(x,t) \]

Thus, the underlying GR solution of a complete PG solution may
be incomplete from GR point of view. A trajectory with finite “proper time”
for infinite true time doesn’t lead to conceptual problems because it is simply
interpreted as “freezing” of physical effects caused by an extremal field.

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— an idea which seems close
to PG.
The most interesting example is the black hole collapse. The complete PG solution here is the part of the GR solution before horizon formation. The PG solution for the big bang is also complete for \( t \to -\infty \). On the other hand, the reverse may be true too. A complete GR solution may be incomplete from PG point of view.

The other essential difference is symmetry. The symmetry group of PG is an affine variant of the Galilei group — a finite dimensional group which includes translations in space and time. A minor consequence is a preference of the flat universe solution in PG. The curved universes are still possible, but no longer homogeneous. Another consequence is the possibility of definition of a local energy-momentum tensor using the Noether theorem. We obtain the well-known energy-momentum pseudotensor:

\[
\tau^{ik} = \frac{c^4}{16\pi k} \left\{ (2\Gamma^p_{ln}\Gamma^p_{np} - \Gamma^p_{lp}\Gamma^p_{mn} - \Gamma^p_{ln}\Gamma^p_{mp})(g^{ik}g^{lm} - g^{ik}g^{lm}) + \\
+ g^{il}g^{mn}(\Gamma^k_{lp}\Gamma^p_{mn} + \Gamma^k_{mn}\Gamma^p_{lp} - \Gamma^k_{lp}\Gamma^p_{lm} - \Gamma^k_{lm}\Gamma^p_{np}) + \\
+ g^{kl}g^{mn}(\Gamma^i_{lp}\Gamma^p_{mn} + \Gamma^i_{mn}\Gamma^p_{lp} - \Gamma^i_{lp}\Gamma^p_{lm} - \Gamma^i_{lm}\Gamma^p_{np}) + \\
+ g^{kl}g^{mn}(\Gamma^i_{ln}\Gamma^k_{mp} - \Gamma^i_{lm}\Gamma^k_{np}) \right\}
\]

The coordinate-dependence of the pseudo-tensor in GR has a natural explanation in PG as the dependence of energy and momentum from the hidden velocity of the ether. Full local energy and momentum densities are simply “hidden variables” in GR too — a natural point of view, because they are dual to the coordinates.

The additional predictions of PG are in good agreement with observation. We have not yet seen any topologically nontrivial solution, and the universe seems to be approximately flat. Nonetheless, this cannot be considered as an experimental verification of PG. At the classical level PG and GR are de-facto identical in their experimental predictions.

\[2\text{This adds evidence that the semiclassical approximation breaks down near the black hole horizon.}\]
4 Quantization of Post-Relativistic Gravity

PG and GR may be distinguished during quantization. It is essentially to remark that quantum PG is a quantum theory with GR as the classical limit, but is not quantum GR and that’s why avoids most of the conceptual problems of GR quantization. It is using the hidden Newtonian structure as a frame for classical quantization.

This solves the “problem of time” in quantum gravity. The concepts of time of GR and non-relativistic quantum mechanics are in contradiction ([8], [10], [2]). “Whatever the final version of quantum gravity is like, as long as the requirement of general covariance is imposed, the quantum theory would seem to have the problem of time” [1]. In quantum PG these two concepts of time are simply defined by two different objects — true time $t$ and clock time $\tau$. By the way, this solves causality-related problems like “uncertain causality” caused by uncertain gravitational field, superluminal tunneling ([18], [5], Bell’s inequality [4].

Together with time and causality, the background space in quantum PG is external and fixed. Obviously this allows to define a position operator, which is meaningless in GR where we have even different topologies. But other observables need this space too. Indeed, after an interaction of a state $|g^1\rangle + |g^2\rangle$ with a test particle $|\psi\rangle$ we obtain a state $|\psi^1\rangle \otimes |g^1\rangle + |\psi^2\rangle \otimes |g^2\rangle$, and the probability that this interaction has changed the initial superpositional state into $|g^1\rangle - |g^2\rangle$ depends on the scalar product $\langle \psi^1 | \psi^2 \rangle$. These two states $|\psi^1\rangle$ and $|\psi^2\rangle$ are the results of evolution on different gravitational background, thus in the semiclassical approximation functions on different solutions. In GR, such a scalar product of functions defined on different solutions is undefined. PG defines it straightforward using the background space.

The situation is similar for other observables too: Local energy and momentum density are not measurable already in classical GR, not to talk about quantum theory. In PG this problem doesn’t exist.

The number of particles of a quantum field is already problematic for a quantum field on a fixed GR background — the definition of the vacuum state is not diffeomorphism-invariant. In PG it is possible to define a scheme which allows to define a unique, “natural” vacuum state depending on the field configuration at a given moment of true time $t$.

Thus, all usual classical observables may be easily introduced into quan-
tum PG, but lead to conceptual problems in quantum GR. But there are also other advantages of quantum PG:

- PG is a theory which is “relativistically but not Lorentz invariant” in Bell’s classification [4]. Thus, the violation of Bell’s inequality may be described by real, hidden mechanisms which violate Einstein’s causality, but not PG causality. Quantum state reduction occurs in the “preferred frame” defined by $t = \text{const}$ (See also Cohen and Hiley [6]).

- The tetrade mechanism may be modified using the subdivision into space and time which is already fixed in PG. This reduction into a triade formalism reduces the resulting gauge group from $SO(3,1)$ to $SO(3)$. The compactness of $SO(3)$ is a great technical advantage (i.e. for lattice gauge theory [3]).

- Because we have well-defined translational symmetry and local energy and momentum densities, the Hamilton formulation is much easier, the canonical quantization scheme doesn’t lead to constraints but to a normal evolution equation.

- We obviously have no problems with topology — no topological foam, no wormholes.

- The different picture of the black hole collapses without an actual part behind the horizon solves the problems related with conservation laws [22].

Full quantization of a nonlinear field theory like PG remains to be a complex problem. But PG allows to solve in a straightforward way many of the fundamental, conceptual problems of GR quantization. It seems that the remaining problems of PG quantization have technical, not conceptual character.

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