Gravity as a Goldstone−Higgs field, instead of a Gauge Field

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Jack Sarfatti wrote:

> "The Question is: What is The Question?" John Archibald Wheeler
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> OK I have been reading the "philofawzy" of the quantum gravity literature and I dimly realize a few things:
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> 1) When The Pundits talk about "gauge invariance" in GR they do not mean what I mean (local gauging of Poincare group to get renormalizable SPIN 1 curved tetrads and torsion spin connections as compensating gauge potentials like in Yang−Mills internal symmetries). They work at the spin 2 geometrodynamic level of the ADM formalism and get stuck on all kinds of physical nonsense such as:

The concept of gravity as a Poincare' gauge field is problematic, at best. This is best explained as follows, which reflects the introductory passage of "Gauge Gravitation Theory"; G. Sardanashvily and O. Zakharov, World Scientific 1992

The geometric nature of gravity (as first discovered by Einstein) arises as a direct result of the Equivalence Principle. In the context of Galilean symmetry, it would lead to the notion of Newton−Cartan spacetimes. In the context of Lorentz symmetry, it leads to General Relativity. Reformulating the latter in terms of fibre bundles as a gauge theory helps to further elucidate the nature of gravity field as being a Higgs−Goldstone field corresponding to the spontaneous breakdown of world symmetries. Specifically, it is the fermions that brings about and makes necessary this extra element.

The main problem with thinking of gravity as a gauge theory is that the field involves the metric/tetrad, whereas gauge potentials in gauge theory are connections. The conventional scheme is to equate the tetrad components h^m_a to the gauge potentials A^m_n associated with the translation generators in the Poincaré group and to try and fit gravity within the mould of a Poincaré gauge theory.

Needless to say, there are a lot of problems with this idea. First and foremost, the Poincaré group isn't compact or semi−simple. So, you lose much of the important machinery associated with gauge theory, which relies on this property. Second, the whole exercise loses sight of the analogous role that Higgs−Goldstone fields play in spontaneous symmetry breaking, in gauge theory, and fails to note the analogy present here. Third, the fit isn't all that good: holonomic transformations fail to be reproduced within the framework, and different types of gauge transformations (atlas transformations, principal morphisms, gauge freedom transformations, etc.) cannot be discerned.

Continuing on from there...

The authors go on to develop a general framework based on the notion of generalized connection. An ordinary connection resides within the well−known theory of principal bundles; or within a bundle associated with a principal bundle. The latter are called principal connections.

A matter field resides within an associated bundle. However, one also has a general concept of "connection" for bundles, independent of any prior notion of principal connections. This is seen as follows.

A bundle Q over a base space M provides you, locally, with a set of coordinates (x^m, q^a) = (x^1,...,x^n, q^1,...,q^N) describing (for instance) a system of N degrees of freedom within a spacetime of n dimensions. As soon as one writes down a first order law for the system configuration, one is also bringing in the "velocities" (v^a_m = @q^a/@x^m) −− the resulting space J^1(Q) with coordinats (x, q, v) is called the "first jet" and is a bundle in two ways:
(1) over the base space J^1(Q) −−> M
(2) over the configuration space J^1(Q) −−> Q.

The latter is particularly of interest. For a velocity field A = v(x,q) when thought of as a function of both the coordinates and configuration is then represented as a SECTION A:: Q −> J^1(Q) in the latter bundle.

This is the general concept of a connection.

The key result related to these concepts is that if the matter field has a gauge symmetry and Q is thereby associated with a principal bundle P that represents that symmetry, then there will also be a "principal connection" Gamma on Q inherited from P. But it won't generally coincide with a general connection A on Q. Instead, there will be a decomposition
A = Gamma + Sigma,
the latter being called a "soldiering form".

In the particular case of interest, the fields are fermion fields, the gauge symmetry is the local frame SO(3,1) symmetry of the Lorentz group, and the principal connection is the "spin connection" out of which ultimately the connection coefficients relating to gravity arise.

But the general connection also has a soldiering form ... and it is out of this that the tetrad ultimately arises.

The tetrad does NOT provide the gauge potentials of a set of translation generators of the Poincaré group. It provides the parameters for the Goldstone−Higgs field associated with the breaking of the global GL(4) symmetry down to the local SO(3,1) symmetry of fermion fields.

The tetrad part of gravity is neither a gauge field, nor a part thereof; but a Goldstone−Higgs field. Among other things, it is essentially a classical field, does not admit quantization in any of the usual ways and (in fact) parametrizes separate state spaces and separate "vacuum phases" associated with each state space. Each different setting of the tetrad corresponds to an inequivalent state space, and between any two of these spaces there are no coherent superpositions.

Despite the book's dating from 1992, this whole line of investigation represents the outgrowth of a long−standing thread of research going back to the 1970's or before and it is still active at present, as a search on arXiv will show. It is quite friendly to the somewhat−related line of development that's taking place with the "covariant Hamiltonian" or "polymomentum" or "deDonder−Weyl/Lepagean" approach which replaces quantization by a 3+1 Hamiltonian by one with respect to a general covariant "Hamiltonian".

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