PROCEEDINGS OF SCIENCE

Einstein’s Mach’s Principle, Superconnections, Higgs Fields and Cosmology

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1. A brief history of inertia and Mach's Principle.

Conceptual physics woke up from its long hibernation when H. Crescas postulated his *infinite absolute space*, as the stage on which physical reality was and is played *forever***, Galileo then conceived *inertia*, a body's *indifference* to changes in its *position* – though still *resisting* changes in its *velocity*, a notion adopted by I. Newton in his *first* law, with *mass* defined as a measure of that *resistance* in his *second* law. Albert Einstein's [1] *Special Theory of Relativity* took care of an unexpected *absolute* element in *velocity space*, namely *the velocity of light*, which *is the same to all observers*, a priviledged status justified by H. Minkowski's geometrical interpretation [2]; in Einstein's *General Theory of Relativity* [3], *the two Principles of Covariance* and *Equivalence* deny any absolute status to both positions and velocities in spacetime. *Inertia* and “free” *masses* thus contradict Relativity, as emphasized by Einstein in his *"Mach's Principle"* argumentation [4] and explained by him as a conjectured *universal* 'matter to matter' interaction - in the Physics of Particles and Fields (PPF) between all quark and lepton fields - generating the *semblance* of inertia (Einstein assumed that this was a magnetic-like component of classical Gravity) through *its effect being dominated at any position by the contributions from the universe's material clusters most distant from that point* [5]. The new interaction's effective coupling *j* should be weak enough for it to have remained undetected to date in measurements of Newton’s constant, etc. To achieve that '*dominance by the farthest'* organizing the material content of the universe in an *onion* of concentric shells, assuming a

European Physical Society
HEP2005 International Europhysics Conference on High Energy Physics
EPS (July 21st-27th 2005) in Lisboa, Portugal

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constant matter density u and denoting the new force's dependence on distance by r^{-n}, a shell's contribution is $4\pi jur^{2-n}dr$. For 'dominance by the farthest', this should be a positive power of *r,* hence $n < 2$.

2. Higgs Fields and Superconnections

In the PPF, quark and lepton matter fields acquire mass [6,7] through the combined action of several Lorentz-scalar *Higgs*-fields $H(x)$, each of which is associated with the *spontaneous breakdown* of some Yang-Mills-like local symmetry group $G(x)$, with residual symmetry subgroup $K(x) \subset G(x), [H, K] = 0$. The Higgs field transforms as an *f*-dimensional representation of *G* with $a:1,2,..f$ real components, one of which a' has a non-vanishing vacuum expectation value $\langle 0|H'(x)|0\rangle = v \neq 0$. The symmetry breakdown thus impacts the $n(g) - n(k)$ generators of the quotient G/K and the corresponding algebraic components of the Yang-Mills field thereby acquire mass and a longitudal component, thus subtracting $n^g - n^k$ degrees of freedom from n^f, i.e. $n^p = n^f - n^g + n^k$ physical components remain for the Higgs field, which may or may not acquire mass and materialize as "Higgs particles".

It has been conjectured [8-11] that each such process is also constrained by a *superconnection*, replacing the symmetry breakdown by a gauge symmetry under a *supergroup* $S \supset G$; thus, the *electroweak* theory [12-14] in which $G: SU(2) \otimes U(1)$, has S: $SU(2/1)$ [8,15,16] yielding $\sin^2\theta_w = .25$, and $m(H') = 2m(W) = 2ev$ before renormalization corrections (*W* – the charged vector-mesons, *e* the electron charge). The *matter fields* considered are massless chiral leptons and quarks. In the superconnection formalism, the matter representations already combine the chiralities and the mass-term so produced connects a left-chiral lepton or quark to a right-chiral lepton or quark. In *Non-Commutative Geometry* the entire Higgs potential is geometrical [17]. Other Higgs fields and superconnections may be involved in the breaking of *GUT* and in *'generation*' systematics. A $P(4,R)$ superconnection produces Einstein's *Riemannian Gravity* from a *Metric-Affine* background [18,19]: $S: P(4,R)$, $G: SL(4,R)$, $K: \underline{SO}(1,3,R) = SL(2,C)$, $H^+: 9+1, H^-: 6$. The H form an anholonomic 2-tensor, symmetrical (9+1) and antisymmetrical (6) and in this case, the $\langle 0|H'|0\rangle \neq 0$ is the trace, and itself does not acquire mass. Several theories with a massless metric-like symmetry-breaker have been suggested in the past in different contexts, e.g. by Ogievetsky as a Nambu-Goldstone field or in Nathan Rosen's two-metrics theory. *Note that the massless λH^4 theory is among the most studied and known to be "safe" as a Q.F.T., should we indeed come across evidence for the Riemannian superconnection.*

3. The Higgs Fields in the Mach role

In the following paragraphs, we raise the possibility that the Higgs fields responsible for the acquisition of mass at the particle level are also implementing the Mach Principle semblance of inertia mass-creation. We deal here with two different modes of operation: in PPF, a quasi-surgical one-shot acquisition of mass and no identifiable donor -- and in GR, the *Mach* interaction with *all matter* in the universe, more like taxation. Can the two modes be performed by the same agent and represent the same process, with the Machian interaction filling up the Higgs syringe? With just one single Higgs field (the *electroweak* 'almost' confirmed todate, we restrict our study to the above two cases, *electroweak* and *Riemannian*, as they seem to represent two modes of action, different in their propagation of the Machian interaction.

A superconnection is a Lorentz scalar supermatrix with even (block-diagonal) sector valued over the symmetry group G connection one-forms $W^g_\mu dx^\mu$, g a basis in G, while the odd sector (off-box-diagonal) is valued over the Higgs fields as zero-forms. *With the vector-meson* W^g_μ *varying like* r^{-2} *the dimensionality of the one-form in the supermatrix fits with an* r^{-1} *behavior and this should also hold for the rest of that matrix, including the Higgs fields.*

The Higgs field's action is *repulsive*, as it "*deposits*" energy rather than withdrawing it. An attractive potential generates a negative *binding*-*energy. The action of the Higgs field is an energy-storage function*. The right-chiral and left-chiral spinors, originally both massless, now *together store* a sizable amount of *positive energy*; the Higgs field has compressed a spring in a *repulsive* action…

In the case of the electroweak Higgs field at the PPF level, the interaction does involve Dirac spinors, in which the Higgs field specifically bridges between the two chiralities. Returning to the Mach level, the Machian interaction has to be everywhere between Dirac systems only. The typical diagram should show the Higgs fork-like coupling L&R in a matter spinor here and the same at the confines of the universe, with in between, along this Higgs propagators, as many quartic couplings as possible, sending off additional such sucking tubes.

The very massive Higgsons of the electroweak case carry $SU(2/1)$ charges, but the range of Yukawa potential for the exhange of a 170 GeV meson being one thousand times shorter than that of the pion, it is hard to see how we could be dealing with "quark-higgson" and "lepton-higgson" plasmas at "macroscopic" distances. At the same time, although the Q.F.T. Higgs coupling is relatively small, it is only through the forced incorporation of the diagrams with multiple appearances of quartic and quadratic Higgson vertices that the upper bound set by the measurements of the gravitational constant on the effective Mach-Higgs coupling to matter might be satisfied.

4. Cosmological Implications

That Higgs fields of Particle Physics indeed also mediate the GR Machian interaction would already represent a considerable conceptual economy. That their action is *repulsive* opens up yet another and perhaps wider such economy, namely, *the provision of the QFT origin of the classical cosmological constant and of the cosmological expansion* and its recently discovered *acceleration* [20]. The *Cosmological Constant* is then the *summed* v.e.v. *of any* such *Higgs fields*, and the *dark energy* making up 70% of the average energy-density in the universe [21] must also represent Higgs fields.

Acknowledgement

After the author's first presentation of these ideas at the 80th anniversary mini-conference in Tel-Aviv, he was informed by Prof. F. W. Hehl about earlier work by H. Dehnen in which General Relativity is assumed to be an "effective" theory replacing a Higgs field, which is then also assigned the role of fulfilling Mach's Principle. The author thanks Prof. Hehl.

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