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Deep Inelastic Gedanken Scattering off Black Holes

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Abstract

We propose a model of quark and lepton subconstituents which extends the Standard Model of particles to the Planck scale and beyond. We perform a Gedanken experiment by scattering a probe deep inside a mini black hole. We assume the result is that at the core of the hole there is a spin $\frac{1}{2}$ (or 0) constituent field, grayon, in Minkowski space. The grayon is proposed to replace the singularity of the hole. The grayon interactions are assumed to provide bound states of three grayons which form the quarks and leptons.

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1 Introduction and Summary

The motivation behind the model described below is to find a way from a phenomenological model of quarks and leptons to a theory beyond the Standard Model (BSM). A brief look at the Standard Model (SM) history shows that it was developed in steps: the weak sector was created from the Fermi four fermion model (1933) to a renormalizable, spontaneously broken electro-weak theory in about 30 years, the strong sector from Deep Inelastic ep Scattering (DIS) and parton model (1968) to Quantum Chromodynamics (QCD) in about 15 years. The status of the present theory, the SM, is good but several questions and problems remain to be solved. Of these we mention the number of arbitrary parameters (some twenty), neutrino masses requiring possibly more parameters, hierarchy and generation problems.

In an attempt to study the generation question of quarks and leptons a model for the first generation quark and lepton subconstituents was suggested in [1]. Each quark and lepton was supposed to consist of three mini black hole preons bound together by a confining interaction. In this note we rewrite the subcolor details, correct the weak sector structure, focus on the mass of the subconstituents, and make a proposal to develop the raw model one step further.

We make a Gedanken experiment of what might happen when exploring a mini black hole deep inside with a probe. We make the assumption (i) that when probed with a very high energy $E \gg E_{Planck}$ point particle a mini black hole Hawking radiates off its energy and becomes undressed as a fermion or scalar core field in Minkowski space. The point-like core particles of the field have a light mass, something like the Higgs or proton mass (or even zero). The core fields are named grayons.

Having come this far it would seem tempting to assume (ii) that the black hole singularity is tentatively replaced by a core field.

Light quark and lepton bound states are formed of three core fermions by (iii) an interaction mechanism that is qualitatively described in Section 2.

Scalar bound states, the ultimate Higgs, may be formed in a similar fashion of three scalar grayons. These scalars supposedly contribute in the formation of the second and third generation quarks and leptons.

This short note presents the basic idea and a list of demanding tasks to study, including developing the calculational methods in the first place. We search a concept, or architecture, that would give answers to the SM problems mentioned in the first paragraph above. Anything inside a black hole has to do with quantum gravity, which is the ultimate future target. The main approaches to quantum gravity are reviewed and problems therein discussed in detail eg. in a recent paper [2].

2 Quarks and Leptons

In the notation of [1] the quark and lepton constituents are a fractionally charged maxon m_i^+ with charge $+\frac{1}{3}$, and a neutral maxon m^0.

The first generation quark and lepton bound states are

$$u : \{(m^+m^+m^0)_r, (m^+m^0m^+)_g, (m^0m^+m^+)_b\} \tag{1}$$
$$\bar{d} : \{(m^-m^0m^0)_r, (m^0m^-m^0)_g, (m^0m^0m^-)_b\} \tag{2}$$
$$e^- : m^-m^-m^- \tag{3}$$
$$\nu_e : m^0m^0m^0 \tag{4}$$

Permutation of the odd grayon in (1) and (2) provides color for quarks whereas the leptons consist of three identical grayons. The sum of grayon charges in (1)-(4) is zero.

These bound states are formed when three free nearby core fermions dress themselves as stable bound states. The binding interaction can be one or more of the following: scalar, Abelian or non-Abelian vector, tensor, or simply, a potential. The form of the potential, say inverse radius, may contain ripples due to fluctuating metric.

The other two generations of quarks and leptons are assumed to be due to the same grayon interactions, including the ultimate Higgs, or other than three grayon states but no detailed mechanism is known at the moment.

The weak interactions are treated, unlike in [1], traditionally as the broken symmetry gauge theory with an elementary Higgs field.

Other subconstituent models are listed in [3]. These sources include more detailed discussions of virtues and problems of subconstituent models.

3 Some Current Theories

Present experiments support the Standard Model (SM) well, and perhaps the SM holds up to or near the Planck scale. The present model is, by construction, consistent with the SM to the Planck scale. Beyond Planck scale ultimately there is quantum gravity, grayon quantum fields in Minkowski space in our setup.

Grand Unified Theory (GUT), like SO(10), and the present model are consistent only in representing basically one generation at a time in one multiplet. They differ significantly in the gauge and Higgs sectors. The present setup goes towards smaller reps rather than larger. The Higgs couplings to SM fermions are replaced in the present scheme by a mechanism discussed in the previous section.

The structures of this model and String Theory are different. It would be interesting to find out whether it is possible to map the grayons to any proper stringy objects that are known to lead to the correct black hole entropy formula [4].

4 Cosmology

In the present scheme the usual Big Bang initial singularity is smoothed into a very high but finite density banging object of grayons and anti-grayons. Quarks and leptons are soon formed from these. This should not lead to major deviations from the standard cosmological model but quantitative differences should be looked for.

For dark matter and dark energy we have nothing readily to propose. There may be, however, a connection between dark matter and scalar grayon configurations.

The formation of stellar size black holes is expected to proceed as in general relativity theory.

5 Experimental tests

Deep inelastic scattering off a black hole is not, of course, within reach of any accelerator on earth (or elsewhere). Details of cosmological evolution and some very high energy astrophysical processes might be of help. The test of the model is rather in developing the calculational methods, internal consistency, and agreement with available experimental results.

6 Connection to early work

This model may be considered as a variation of earlier work of Einstein, Infeld and Hoffmann [5] who studied the case that elementary particles are singularities of spacetime.

7 Conclusions

The present note contains speculative thoughts how to go beyond the Standard Model towards a model of Planck scale phenomena. We believe that this is the arena of quark and lepton substructure where it may be possible to solve both the hierarchy and generation problems, and have a preliminary view of quantum gravity. This implies that valid equations are developed and crucial details are worked out.

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Einstein published a series of papers on this between 1927 and 1949.