**Higgs Essay**

# Open Challenges of the Higgs Sector

Ervin Goldfain*

Photonics CoE, Welch Allyn Inc., Skaneateles Falls, NY 13153, USA

## Abstract

Despite being generously supported by experimental data, the Standard Model for particle physics (SM) has many unsettled questions. At least for the time being, the discovery of the Higgs boson - a crucial step in the validation of the SM – does not take us any closer to answering these questions. With no clear roadmap in sight, the Higgs sector of particle physics remains a largely unexplored territory.

**Key words**: Standard Model, Higgs sector, open challenge, particle physics.

An incomplete record of outstanding issues is listed below. As the Higgs sector is, by design, an integral part of the SM, it is our view that many SM-related issues necessarily overlap with the Higgs-related ones. For the sake of brevity, only a limited number of references are included here.

1) The fine-tuning problem (also known as the "naturalness" or the "gauge hierarchy" problem) [1-2, 4, 5-6].
2) The unknown source of the Higgs mass and of the electroweak scale [1, 3-5].
3) The triviality problem and its possible resolution in the presence of gauge fields [1-3].
4) Unsolved aspects of the link between the Higgs sector and the cosmological constant [1].
5) Implications of Haber's theory on the Decoupling Limit [4].
6) The Higgs di-gamma channel violates gauge invariance in exactly four dimensions [6].
7) Is there closure on Veltman's objections? [7-9].
8) Is there closure on the implications of the Coleman-Weinberg mechanism? [3,10].
9) The quartic coupling of the Higgs boson not measured yet, its effect on the potential only inferred at this point.
10) No clue on the pattern of fermion masses and couplings.
11) No clue on the origin of CP violation and baryon asymmetry.
12) No clue on neutrino oscillations/mixing.
13) No clue on the origin of the g-2 anomaly.
14) No clue on why the SM has the *U(1) x SU(2) X SU(3)* gauge structure.
15) Many aspects of Quantum Chromodynamics (QCD) are left unclear [11].

* Correspondence: Ervin Goldfain, Ph.D., Photonics CoE, Welch Allyn Inc., Skaneateles Falls, NY 13153, USA
E-mail: ervingoldfain@gmail.com

16) No proven connection between the SM and Beyond SM physics (Dark Matter and Quantum Gravity in particular).

## References

[1] http://arxiv.org/pdf/hep-ph/0703280.pdf
[2] http://arxiv.org/pdf/1308.0545v1.pdf
[3] http://arxiv.org/pdf/1301.4224v2.pdf
[4] http://arxiv.org/pdf/1208.5152v2.pdf
[5] http://arxiv.org/pdf/1206.7114v2.pdf
[6] http://arxiv.org/pdf/1306.5767v1.pdf
[7] http://www.nikhef.nl/pub/theory/academiclectures/Higgs.pdf
[8] Available at the following site: http://igitur-archive.library.uu.nl/phys/2005-0622-155143/ReflectionsoftheHiggssystemVeltman.pdf
[9] http://adsabs.harvard.edu/abs/1986SciAm.255...76V
[10] http://arxiv.org/pdf/1303.5897v1.pdf
[11] http://www.slac.stanford.edu/cgi-wrap/getdoc/slac-pub-15274.pdf