

## **Open Challenges of the Higgs Sector**

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### Abstract

*Although highly accomplished experimentally, the Standard Model for particle physics (SM) carries a heavy load of unsettled questions. At least for the time being, the discovery of the Higgs boson - a crucial step in the validation of the SM – does little to ease the burden of successfully closing these questions. With no clear roadmap in sight, the Higgs sector of particle physics remains a largely unexplored territory.*

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].
- 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.
- 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 an underlying  $U(1) \times SU(2) \times SU(3)$  gauge structure.
- 15) No proven connection between the SM and Beyond SM physics (Dark Matter and Quantum Gravity in particular).

### **On line 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/ReflectionsoftheHigssystemVeltman.pdf>

[9] <http://adsabs.harvard.edu/abs/1986SciAm.255...76V>