Contribution ID: **5** Type: **not specified**

How special is the particle physics Standard Model?

Monday, 12 February 2024 13:00 (1 hour)

The Standard Model describes very well the results of our present experiments, from low energy precision measurements up to 13 TeV collisions at the LHC. How high in energy might it still work without need for new physics? Mathematically it is self-consistent up to the Planck scale. Physics-wise, if one extrapolates the Standard Model up to the Planck scale using renormalization group evolution, one finds that the vacuum is within about one standard deviation of being stable with any metastability setting in above 10^10 GeV. On the other hand, there are open puzzles: the tiny neutrino masses, the matter-antimatter asymmetry in the Universe, fermion families (why are there 3?), dark energy and dark matter plus primordial inflation. Here we give an introduction to these open questions and discuss how they might be resolved within the framework of an emergent Standard Model, with gauge symmetries "born" in a topological-like phase transition (without global order parameter) and dissolving in the extreme ultraviolet (instead of extra unification).

References:
SD Bass, Philosophical Transactions of the Royal Society A 382 (2023) 20230092, https://doi.org/10.1098/rsta.2023.0092

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