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Weak Gravity Conjecture, Multiple Point Principle and the Standard Model Landscape

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The requirement for an ultraviolet completable theory to be well-behaved upon compactification has been suggested as a guiding principle for distinguishing the landscape from the swampland. Motivated by the weak gravity conjecture and the multiple point principle, we investigate the vacuum structure of the standard model compactified on S^1$ and T^2. The measured value of the Higgs mass implies, in addition to the electroweak vacuum, the existence of a new vacuum where the Higgs field value is around the Planck scale. We explore two- and three-dimensional critical points of the moduli potential arising from compactifications of the electroweak vacuum as well as this high scale vacuum, in the presence of Majorana/Dirac neutrinos and/or axions. We point out potential sources of instability for these lower dimensional critical points in the standard model landscape. We also point out that a high scale AdS_4 vacuum of the Standard Model, if exists, would be at odd with the conjecture that all non-supersymmetric AdS vacua are unstable. We argue that, if we require a degeneracy between three- and four-dimensional vacua as suggested by the multiple point principle, the neutrinos are predicted to be Dirac, with the mass of the lightest neutrino O(1-10)meV, which may be tested by future CMB, large scale structure and 21cm line observations.

Presenter: HAMADA, Yuta (University of Wisconsin-Madison, KEK)

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