Snowmass2021 - Letter of Interest

Moduli Stabilization and Landscape Statistics

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NF Topical Groups: (check all that apply □/■)
■ (TF01) String theory, quantum gravity, black holes
■ (TF08) BSM model building

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Abstract: This Letter of Interest proposes to study statistical distributions in the string landscape of quantities of interest for phenomenologists. The statistics of such quantities, for example the supersymmetry breaking scale, has been extensively studied in the past. However, the effects of Kähler moduli stabilization on the distributions has not been systematically addressed. The implications can be quite drastic – for example, in type IIB flux compactifications one generally obtains unstable vacua when the F-terms of the dilaton and the complex structure moduli are larger than the F-terms of the Kähler moduli. This implies that the distribution of the supersymmetry breaking scale, as well as other quantities like the mass and couplings of ALPs, can be understood only after a detailed study of Kähler moduli stabilisation. We propose to study the implications of moduli stabilization on statistical distributions in the landscape.

In Ref. [1], we studied distributions of the SUSY breaking scale, finding either a power-law behaviour induced by uniform distributions of F-terms or a logarithmic distribution motivated by dynamical supersymmetry breaking. It is the stabilisation of the Kähler moduli which determines how the relevant F-terms are distributed and how dynamical supersymmetry breaking affects the distribution of the gravitino mass. We found that the distribution of the supersymmetry breaking scale is power-law only in KKLT and perturbatively stabilised vacua which therefore favour high scale supersymmetry. On the other hand, LVS vacua feature a logarithmic distribution of soft terms and thus a preference for lower scales of supersymmetry breaking than KKLT vacua. LVS models also offer explicit examples where the distribution of the supersymmetry breaking scale is clearly decoupled from the one of the cosmological constant. Whether the landscape of type IIB flux vacua predicts a logarithmic or power-law distribution of the supersymmetry breaking scale thus depends on the relative preponderance of LVS and KKLT vacua.

The philosophy of incorporating Kähler moduli stabilisation while studying the distributions in the landscape is also relevant for other physically relevant quantities. At present we are carrying out such studies for the masses and couplings of ALPs and investigating the implications for ALP physics and the dark matter abundance. Our study will also incorporate connections with ΔN_{eff}, the cosmological moduli problem, and implications for non-standard cosmological histories. We will explore the distribution of the relevant quantities in three scenarios for Kähler moduli stabilisation in type IIB: (*i*) models with purely non-perturbative stabilisation like in KKLT vacua; (*ii*) models where the Kähler moduli are frozen by balancing perturbative against non-perturbative effects as in LVS models; and (*iii*) models with purely perturbative stabilisation.

Statistical studies of the landscape have been carried out by other groups using random matrix theory and machine learning techniques [2–5]. Our proposal will provide novel and important complementary insights to this program.

References

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