Counting F-theory base polytopes

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Abstract

We propose a new statistical ensemble of toric bases for elliptic Calabi-Yaus used in F-theory models, by focusing on only the convex hull of the base, i.e., the base polytope. This physically motivated coarse-graining greatly simplifies the combinatorial complexity of the part of the 4d F-theory landscape with toric bases. We develop a Monte Carlo approach that randomly samples the base polytopes within fixed boxes, with proper statistical weights. We first apply the algorithm to the set of 2d base polytopes, generating an enlarged set of toric 2d bases that include certain types of codimension-two (4,6) points, and we validate our approach against exact numbers. We then explore the set of 3d base polytopes which fit in a set of "maximal" 3d boxes, and estimate the total number of inequivalent 3d base polytopes to be 1085–1090. We provide statistical data such as the distribution of non-Higgsable gauge groups on these bases. Amusingly, a similar method can also be applied to generate reflexive polytopes in various dimensions. In both the reflexive and base polytope cases, the number of relevant polytopes obeys a Gaussian distribution as a function of the number of vertices, which can be understood in terms of other results on random polytopes in the math literature.

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