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Short Tops and Semistable Degenerations

One may construct a large class of Calabi-Yau varieties by taking anticanonical hypersurfaces in toric varieties obtained from reflexive polytopes. If the intersection of a reflexive polytope with a hyperplane through the origin yields a lower-dimensional reflexive polytope, then the corresponding Calabi-Yau varieties are fibered by lower-dimensional Calabi-Yau varieties. A top generalizes the idea of splitting a reflexive polytope into two pieces. In contrast to the classification of reflexive polytopes, there are infinite families of equivalence classes of tops. Tops may be used to describe either fibrations or degenerations of Calabi-Yau varieties. We give a simple combinatorial condition on tops which produces semistable degenerations of K3 surfaces, and, when appropriate smoothness conditions are met, semistable degenerations of Calabi-Yau threefolds. Our method is constructive: given a fixed reflexive polytope which will lie on the boundary of the top, we describe an algorithm for constructing tops which yields semistable degenerations of the corresponding hypersurfaces. The properties of each degeneration may be computed directly from the combinatorial structure of the top.