Abstract

In this thesis we study the classical de Sitter scenario in type II string theories: in a regime where string corrections to the effective theory are negligible, we analyze de Sitter solutions in flux compactifications with orientifolds – a crucial area for linking string theory to cosmological models. In particular, we explore classical scalar potentials derived from string theory and study in detail the constraints on the existence of their critical points. These extrema correspond to solutions with maximally symmetric spacetimes, including (anti-)de Sitter and Minkowski. Our results reveal that classical flux compactifications leading to d-dimensional (quasi-)de Sitter solutions face strong constraints on their existence. These no-go theorems categorically exclude classical de Sitter in dimensions $d \geq 7$, revealing a preference for four-dimensional spacetimes. This is rigorously checked by computing the parameter c of the de Sitter Swampland Conjecture for each no-go theorem, showing consistency with the bounds given by the Trans-Planckian Censorship Conjecture, with numerous saturation cases in dimensions $d > 3$. This analysis demonstrates a profound agreement between the low-energy limits of string theory and cosmology, while strengthening the validity of the proposed bounds.

In addition, the newly proposed Anti-Trans-Planckian Censorship Conjecture introduces a framework for characterizing negative scalar potentials in the quantum gravity effective theory. This conjecture states that in a contracting spacetime, modes squeezing to sub-Planckian lengths challenge the validity of the effective theory. As a consequence, it imposes bounds on the potential and its derivatives in the asymptotics of field space, which have been tested in various string compactifications. By extending these bounds to anti-de Sitter solutions characterized by radius l, we predict the presence of a scalar field with mass m satisfying $m^2 l^2 \lesssim -2$. This result has significant implications for the corresponding dual conformal field theory.

Recent constructions propose the existence of de Sitter solutions in models with O8-planes/D8-branes that circumvent a classical no-go theorem via unusual sources or, equivalently, corresponding boundary conditions on the bulk fields. Motivated by the ongoing debates on whether these sources arise in classical supergravity, we explore a minimal extension of the classical de Sitter scenario by including 4-derivative corrections in the α' expansion of the O-plane/D-brane action. While higher-order terms and bulk corrections are of minor importance, our analysis shows that even this extended model fails to yield the desired solutions; a conclusion that extends to models with additional O6-planes/D6-branes.

Keywords: string theory, supergravity, de Sitter, D-brane, orientifold