Higher Order Constraints on Heterotic String Compactifications

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Based on work with
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Introduction and Motivation

- Compactification of string theory down to four dimensions has still many open problems.
- Getting positive (non-zero) cosmological constant.
- Much progress has been made in type IIB, much more than in other theories.

Introduction and Motivation

- Compactification of 10D Heterotic supergravity to maximally symmetric 4D space-time leads to trivial Minkowski space.
- Recent work indicates that higher order tree-level corrections together with warping might change this.
- AdS4 solution might be possible!

Green, Martinec, Quigley, Sethi [1110.0545]

Introduction and Motivation

- But, by further inspection, it's not possible.
- In fact, Minkowski is the only solution to all orders in the derivative expansion (perturbative, tree-level.)

I will use my time here to explain this result.

A No-go Theorem: Assumptions

$$S=\int\sqrt{-g_{10}}\,e^{-2\phi}\left\{R_{10}+4(\nabla\phi)^2-\frac{1}{2}|H|^2+\cdots\right\}d^{10}X$$

We assume

- That 10D space-time is a warped product space of four dimensional external space-time and a six dimensional internal space.

$$ds^2=e^{2A(y)}g_{\mu\nu}(x)\,dx^\mu dx^\nu+G_{mn}(y)\,dy^m dy^n$$

- Space-time is maximally symmetric. (No space-time filling fluxes.)
- The action above can consistently be truncated at any order in α'

A No-go Theorem: 4D action

Pulling out the dilaton modulus:

$$\tilde{g}_{\mu\nu} = Vol\,\tau^2 g_{\mu\nu}$$

Where

$$e^{-\phi} = \tau e^{-\phi_{kk}}, \quad Vol = \int \sqrt{G}\, e^{-2\phi_{kk}+2A} d^6 y$$

The four dimensional action now takes the form

$$S = \int \sqrt{-\tilde{g}} \{ \tilde{R}_4 - V + W \} d^4 x$$

V is the effective potential but W is a sum of terms that are formed by contracting external indices.

A No-go Theorem: EOM

The four dimensional dilaton equation is

$$2\mathrm{V} + \tau \partial_\tau W = 0$$

and the four dimensional traced Einstein equation is

$$\tilde{R}_4 - 2\mathrm{V} - W' = 0$$

Combined, they give

$$\tilde{R}_4 = -\tau \partial_\tau W + W'$$

A No-go Theorem: EOM

All terms of W contain contractions of external indices, but by maximal symmetry of space-time, the only objects with external indices are:

$$\tilde{g}_{\mu\nu} \quad \tilde{R}_{\mu\nu\rho\sigma} \quad \tilde{\epsilon}_{\mu\nu\rho\sigma}$$

This means that all terms of W contain positive power of the external Riemann tensor. The same holds for the right hand side of our equation:

$$\tilde{R}_4 = -\tau \partial_\tau W + W'$$

Using the form of the Riemann tensor for maximally symmetric space-time, we can write our equation in terms of the CC:

$$\Lambda = \sum_{m,n>0} c_{mn} \alpha'^m \Lambda^n$$

A No-go Theorem

Using the assumption that the low-energy action can be consistently truncated at each order, means that the corrections are ordered hierarchically and we can solve our equation

$$\Lambda = \sum_{m,n>0} c_{mn} \alpha'^m \Lambda^n$$

order by order in α':

$$\Lambda = \Lambda_0 + \alpha' \Lambda_1 + \alpha'^2 \Lambda_2 + \cdots$$

Which immediately gives the result

$$\Lambda = 0$$

Discussion and Summary

- Compactification of perturbative tree-level heterotic string theory to four dimensional maximally symmetric space-time yields the trivial Minkowski solution.
- The argument also holds for other theories, but then we must assume all space-time fluxes are zero, and all localized sources are absent.
- We can use this result to predict that loop corrections or non-perturbative corrections are required to get non Minkowski space-time.
- By analyzing the first loop correction to heterotic theory (which is known) we might be able to determine the sign of the cosmological constant for general compactifications.