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Nonperturbative corrections to the Kähler potential

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We present the results of a detailed investigation into the consequences of adding specific string motivated non-perturbative corrections to the usual tree level Kähler potential in dilaton dominated scenarios. The success of the model is judged through our ability to obtain a realistic vacuum expectation value for the dilaton $\langle \text{Re}S \rangle \sim 2$, corresponding to the true minima of the scalar potential and being associated with a reasonable value for the supersymmetry breaking scale via the gravitino mass. The status of the so-called moduli problem is also reviewed in each of the *Ansätze* studied. Those include previous proposals made in the context of both the chiral and the linear multiplet formalisms to describe gaugino condensation, and a new *Ansatz* which shows explicitly the equivalence between the two.

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I. INTRODUCTION

There are a number of pressing issues that any string based scenario of supersymmetry (SUSY) breaking needs to address. They include the stabilization of the dilaton with an acceptable phenomenological value as it has Planck mass suppressed couplings with all the matter fields, the stabilization of the moduli fields as they determine the size of the extra dimensions, the successful breaking of supersymmetry at low energies and the notoriously difficult cosmological constant problem. In many ways, these issues are related to each other. If the dilaton field is stabilized with anything other than zero potential energy associated with it then there exists a residual cosmological constant. Over the past few years as interest in string phenomenology has exploded there has been much progress made in addressing these issues, in particular in the context of gaugino condensation as the source of SUSY breaking [1]; but it is fair to say, no totally satisfactory resolution has yet been obtained. However a few steps forward have been made and it is possible to describe hierarchical SUSY breaking and a non-trivial potential $V(S)$ for the dilaton S (recall $\text{Re}S \sim g_{\text{gut}}^{-2}$) [2]. With two hidden condensates and the presence of hidden matter it was possible for the dilaton to dynamically acquire a reasonable vacuum expectation value (VEV) ($\text{Re}S \sim 2$), with SUSY being broken at the correct scale $m_{3/2} \sim 1$ TeV, where $m_{3/2}$ is the gravitino mass. Unfortunately the dilaton was always stabilized leaving a negative cosmological constant [3]. Moreover, the potential barrier which defined the minima was extremely small on the weak coupling side of the field, leading to potential problems associated with stabilizing the field in the context of cosmology [4].

More recently the issue of stabilizing the dilaton and its relation to gaugino condensation has been considered in the light of alternative approaches [5]. Also, Casas [6] and Binétruy and collaborators [7,8] have investigated possible

string induced non-perturbative corrections that the Kähler potential is likely to experience. Specific forms for these corrections were also introduced, motivated from string considerations [9]. An important feature that emerged was that it became possible to obtain a minimum of the potential at the realistic value $S \sim 2$ with just one condensate.

In this paper, we examine in far greater detail than has previously been undertaken the predictions arising out of these non-perturbative corrections. In Sec. II we introduce the analysis of the one condensate model and describe the types of non-perturbative corrections introduced by Casas [6]. We then describe the various constraints imposed on the model, hence on the available parameters by demanding physically sensible values for $\langle S_0 \rangle$, $m_{3/2}$ and $V(S_0) = 0$ at the minimum. It turns out to be nontrivial obtaining all three conditions together, and in the cases where it can be done, the price that is paid is a very low potential barrier for the dilaton to overcome and large values of the parameters. Demanding the dilaton is properly stabilized at a reasonable value generally causes the gravitino mass to become unrealistically large. However, the moduli problem could be solved by this mechanism. The dilaton mass turns out to be inversely proportional to K'' , the second derivative of the Kähler potential, which approaches zero at the minimum of the potential. Hence the mass becomes large compared to the gravitino mass. In Sec. III we relate our results with those obtained by Binétruy, Gaillard and Wu [7,8] who also investigate non-perturbative corrections but based on the linear multiplet formalism. The comparisons are very encouraging, they demonstrate the equivalence of the two approaches in that it is possible to relate the potentials in the two cases. In particular we show that the results in [7,8] correspond to those in [6] over a particular range of parameters. We conclude in Sec. IV.

II. THE CHIRAL MULTIPLYET FORMALISM

The scalar potential in any $N=1$ supergravity (SUGRA) model is given by

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$$V = e^K |W|^2 \left[\left(K^i + \frac{W^i}{W} \right) (K_j^i)^{-1} \left(K_j + \frac{\bar{W}_j}{\bar{W}} \right) - 3 \right] \quad (1)$$

where K is the Kähler potential, W is the superpotential and the subindices i, j represent derivatives of these two functions with respect to the different fields.

We are going to concentrate on models of SUSY breaking via gaugino condensation [1]. These have been extensively studied in the literature, and we know that the form of the superpotential for one condensate must be

$$W(S, T) = C e^{-\alpha S} / \eta^6(T) \quad (2)$$

where $\alpha = 8\pi^2/N$, $C = -N/(32\pi^2 e)$ if the hidden sector group is $SU(N)$ with no matter fields. The $\eta^{-6}(T)$ dependence ensures the correct transformation of W under the $SL(2, Z)$ target space modular symmetry. For this superpotential Eq. (2) and the standard tree level Kähler potential $K_0(T) = -3 \log(T + \bar{T})$ it has been shown that the scalar potential in Eq. (1) settles to a minimum at $T = 1.2$ [10,3] and all others values related to this by the above-mentioned modular symmetry. Therefore we shall assume such a value for T in the rest of this paper and concentrate on studying the the S dependence of the scalar potential. In practice this means that we are nearly in a dilaton-dominated regime [11], where $i = S$, $j = \bar{S}$ in Eq. (1), and then the scalar potential reduces to¹:

$$V = e^K \left| \frac{C e^{-\alpha S}}{\eta^6(T)} \right|^2 \left[\frac{|K^S - \alpha|^2}{K_{\bar{S}}^S} - 3 \right]. \quad (3)$$

We want to perform a full analysis of what the behavior of this potential is when the Kähler potential receives string non-perturbative corrections. This issue has been suggested in the literature and, moreover, it is not unreasonable to believe that these corrections can be sizable and of the form $g^{-p} e^{-b/g}$, where g is the string coupling constant [9]. Note that this functional form vanishes in the weak coupling limit ($g \rightarrow 0$, i.e., $\text{Re}S \rightarrow \infty$), where we believe perturbation theory to work, whereas they can indeed be important in magnitude around the region where we expect the dilaton to be stabilized ($\text{Re}S \sim 2$ in Planck units) and therefore can play a very important role in the whole process of SUSY breaking.

We shall adopt from now on the parametrization of Ref. [6], which was motivated by the exponential dependence of the Kähler potential K in the scalar potential Eq. (1). Namely we shall study the following two cases:

$$K(\text{Re}S) = K_0(\text{Re}S) + K_{np}(\text{Re}S) \quad (4)$$

and

¹Note that, strictly speaking, the term proportional to -3 in Eq. (3) should be modified to $-3(1 - |1 + 2(T + \bar{T})/(1/\eta)(\partial\eta/\partial T)|^2)$ in order to include the contribution from $i = T$, $j = \bar{T}$ in Eq. (1). However its numerical effect on the final result when this extra term is evaluated at the minimum value of $T = 1.2$ is negligible and, moreover, it has no qualitative consequences in the minimization along the S direction.

$$e^{K(\text{Re}S)} = e^{K_0(\text{Re}S)} + e^{K_{np}(\text{Re}S)} \quad (5)$$

with $K_0 = -\log(2\text{Re}S)$ the usual tree level piece (we shall neglect one-loop corrections as they are irrelevant for the discussion) and where K_{np} in Eq. (4), and $e^{K_{np}}$ in Eq. (5) are the string non-perturbative corrections given by [9]

$$d g^{-p} e^{-b/g} = d(\text{Re}S)^{p/2} e^{-b\sqrt{\text{Re}S}} \quad (6)$$

where d, p and b are constants and we impose $b > 0$ in order for the correction to vanish in the weak coupling limit² (i.e., when $\text{Re}S \rightarrow \infty$).

Our goal is to perform a full analysis of the parameter space determined by the three unknown constants, d, p and b , in order to find under which conditions the scalar potential will have a minimum at a realistic value for the dilaton ($\text{Re}S \sim 2$ in Planck units), with a reasonable gravitino mass ($m_{3/2} = M_p e^{K/2} |W| \sim 1 \text{ TeV}$) and, ideally, zero cosmological constant. For that purpose it is useful to realize that the presence of a second term in the Kähler potential implies that for some values of these parameters its second derivative may vanish. Notice that such a derivative is the factor that multiplies the kinetic term for S in the SUGRA Lagrangian, and therefore the requirement of having a physically meaningful dilaton imposes $K_{\bar{S}}^S > 0$ (or, equivalently, $K'' > 0$, where a prime denotes derivative with respect to $\text{Re}S$).

This constraint is shown in Fig. 1(a) for the case defined by Eq. (4), where the condition $K'' = 0$ for $\text{Re}S = 2$ represented by the solid lines determines the physically meaningful region (i.e. the hatched region) in the plane p vs d , for reasonable values of the latter; here we have taken $b = 1$ and a typical gauge group, $SU(5)$, which basically ensures a reasonable gravitino mass at the minimum of the potential. Unfortunately it can be seen that a simultaneous solution to the conditions $V'(\text{Re}S = 2) = 0$ (dashed lines) and $V(\text{Re}S = 2) = 0$ (dotted lines) always lies within the unphysical region. At most we can have extrema which are compatible with the condition $K'' = 0$; these correspond to the examples of minima next to a singularity of the potential already mentioned in Ref. [6]. Moreover, we have checked that it is possible to fine-tune the value of d to a number of decimal figures so that the singularity reduces to a maximum, its height depending on the amount of fine-tuning we impose. However in all cases the value of the cosmological constant is always positive and large.

There do exist solutions in which a minimum with zero cosmological constant occurs within the physical region, but they correspond to very large values of the parameters d and p ($d \sim 10^{32}$, $p \sim -210$). We have checked that these minima with zero cosmological constant can be found for more reasonable values of the parameters by changing the gauge group. For example $d \sim 130$, $p \sim -10$ would correspond to a case with $SU(80)$ ($b = 1$) in the hidden sector, which, unfortunately, implies a very big gravitino mass.

Fixing p and changing b leads to the same kind of picture emerging as can be seen in Fig. 1(b), where we have focused

²Notice that we do not impose any requirement on the sign of p , that is on the behavior of the non-perturbative correction at strong coupling.

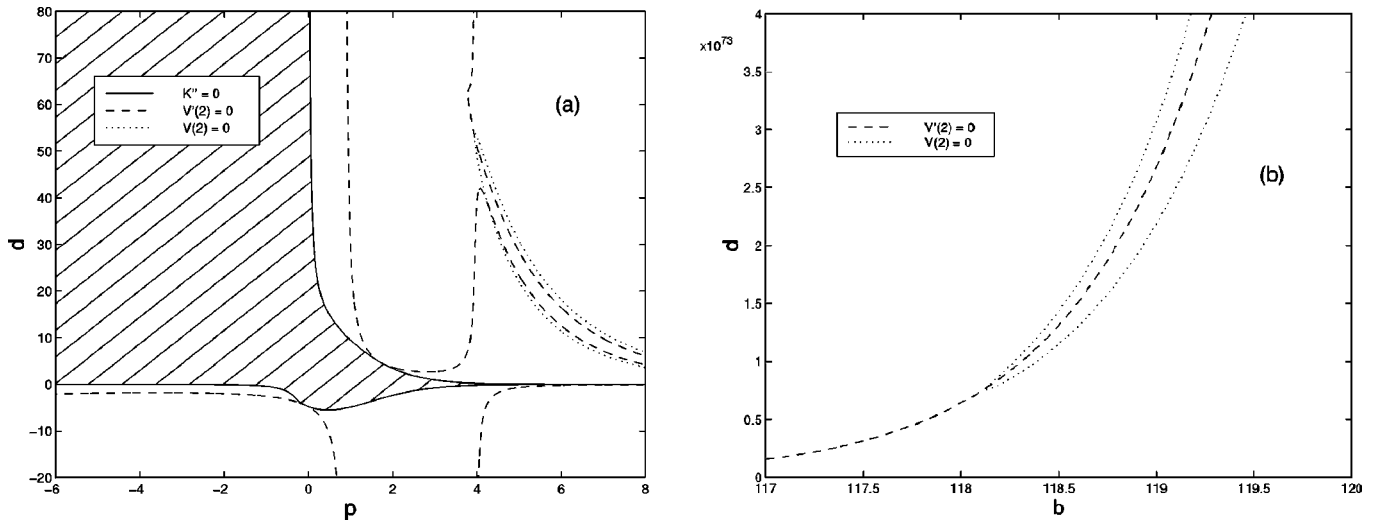


FIG. 1. (a) Contour lines of $K''=0$ (solid lines), $V'=0$ (dashed lines) and $V=0$ (dotted lines) in the p vs d plane for $b=1$, $\text{Re}S \sim 2$ and gauge group $SU(5)$. The hatched region corresponds to the requirement $K''>0$; (b) Detail of a region with $p=-3$ and $K''>0$ in the b vs d plane and gauge group $SU(5)$. As before the dashed lines indicate contours of $V'=0$ and the dotted ones, contours of $V=0$.

on the physically allowed region which admits a minimum with zero cosmological constant for $d \sim 7 \times 10^{72}$ and $b \sim 118$. It corresponds to $p = -3$ and gauge group $SU(5)$, and the corresponding gravitino mass is reasonable (~ 100 GeV). It is convenient to keep in mind this particular example as we shall come back to it in the next section. In general these solutions are characterized by extremely large values of d , which make them look not too attractive. However we could always rewrite the *Ansatz* in a different way so that d gets redefined in terms of another constant which acquires then reasonable values.

Turning to the second form for K_{np} , Eq. (5), the situation is much more complicated from the point of view of obtaining an analytic solution to the conditions $V=V'=0$ for a reasonable value of $\text{Re}S$ and $K''>0$. Therefore we are unable to produce plots analogous to Fig. 1. From Eq. (5) e^K has to be positive definite, consequently there is always a lower bound on the possible values for d . As before we find that minima with positive V_0 are always associated with a singu-

larity of the potential defined by $K''=0$. Analogously to the case defined by Eq. (4), we can fine-tune the value of the parameters to reduce the singularity to a maximum, as shown in Fig. 2. It is clear that, depending on the accuracy with which we define d , the height of the barrier will change. This is particularly relevant for the cosmological properties of these kind of potentials, which we shall discuss below. Figure 2 (a) corresponds to a situation in which both the VEV of the dilaton and the gravitino mass are reasonable (i.e., ~ 2.22 and ~ 5 TeV, respectively), whereas in (b) the minimum corresponds to a phenomenologically acceptable value for the dilaton (~ 1.4) with the gravitino mass too large ($\sim 10^{12}$ GeV) to give rise to a realistic spectrum at low energies.

As mentioned in the Introduction, we are interested in studying the shape of the dilaton potential in order to find out whether these non-perturbative corrections would alleviate its steepness, which is one of the main problems pointed out in [4] to build a realistic model of inflation based on superstrings. The answer to that question is again given by Fig. 2.

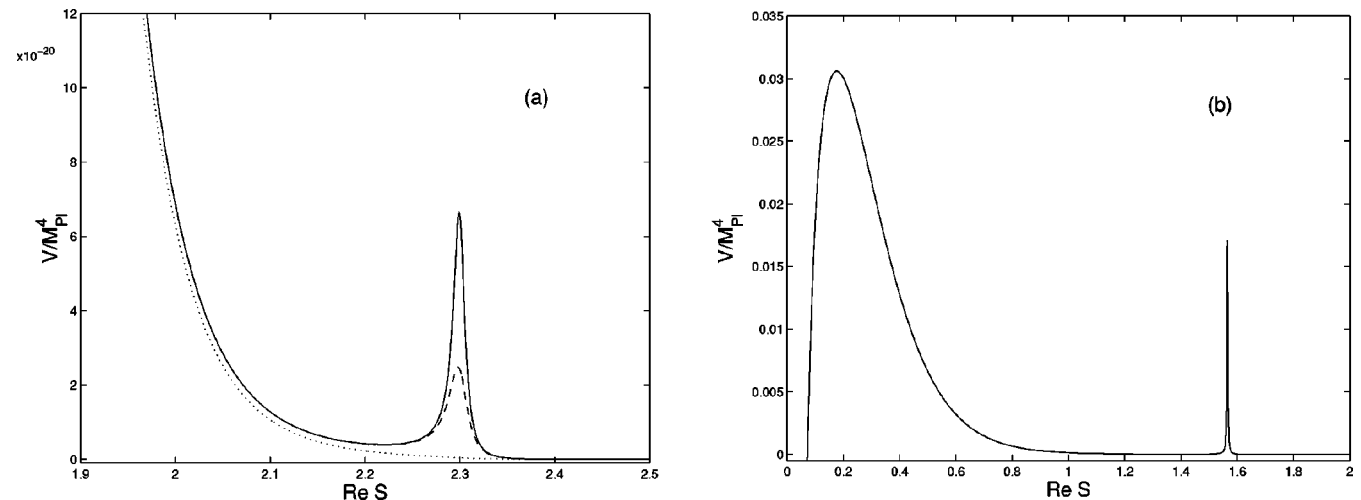


FIG. 2. Plot of the scalar potential V vs $\text{Re}S$ for one condensate and K given by Eq. (5). The values of the different parameters are: (a) $p=1.1$, $b=1$, and $d=5.7391$ (solid), $d=5.739$ (dashed), $d=5.73$ (dotted). The gauge group is $SU(6)$. (b) $p=1$, $b=1.1$, and $d=10.3775$. The gauge group is $SU(11)$.

There we can see that, as already mentioned in [4], the bigger the gauge group is, the more favorable the situation becomes in order to trap the dilaton in its minimum when it is rolling down from the strong coupling regime. As a difference with [4] the cosmological constant is positive now and also the presence of the singularity allows us to tune the height of the barrier to a certain extent. Figure 2(a) is analogous to the several condensate case studied in [4] where the steepness of the potential for small values of S prevents the dilaton from settling down at the minimum. However, Fig. 2(b) shows a nice shape for the potential, which would eventually drag the dilaton to its minimum independently of the initial conditions, but at the price of not having a successful phenomenology. Alternatively it is known that exponential potentials allow the existence of scaling solutions of the corresponding scalar field [12]. We are currently exploring the possibility that such a mechanism could stabilize the dilaton in the context of inflation [13].

However there is a second cosmological issue which might be solved in the context of non-perturbative corrections and it concerns the so-called moduli problem [14]. It is well-known that the masses of the dilaton and moduli in a scenario of SUSY breaking in the context of superstrings with zero cosmological constant are of the order of the gravitino mass, and that causes potential problems given their late decay; in general we can express the mass of the dilaton as

$$m_S^2 = \frac{V''}{K''} \Bigg|_{\min} = \frac{V_0}{M_P^2} \frac{P}{(K'')^3} + m_{3/2}^2 \frac{Q}{(K'')^3}, \quad (7)$$

where V_0 is the potential energy at the minimum, and P and Q are given by

$$P = (K'')^3 - K'''K'' + (K''')^2, \quad (8)$$

$$Q = 2(K'')^2[(K' - 2\alpha) + K'''] - 3[K'''K''(K' - 2\alpha) + K''K''' - (K''')^2], \quad (9)$$

where α is defined after Eq. (2). The crucial point here is to recall that the minimum of the potential in our case lies very close to the point at which $K'' = 0$. This means that the presence of the $(K'')^{-1}$ factor (which comes from the normalization of the kinetic term for the S field) induces an enhancement in the mass of several orders of magnitude. For example, in Fig. 2(a) $m_S \sim 2 \times 10^7 m_{3/2}$, with $1/K'' \sim 10^5$, whereas in Fig. 2(b), $m_S \sim 2 \times 10^5 m_{3/2}$, with $1/K'' \sim 5 \times 10^3$ (note that the contribution from the term proportional to the cosmological constant is the dominant one).

In conclusion, we have seen that it is possible to obtain solutions to some of the most interesting problems associated to the phenomenology and cosmology of string-inspired models with these naive *Ansätze* for non-perturbative corrections to the Kähler potential. Therefore it is reasonable to think that more elaborate forms for K_{np} could lead to even more promising results, and in this framework we proceed to study other proposals.

III. THE LINEAR MULTIPLIET FORMALISM

Having discussed in detail the *Ansätze* for nonperturbative corrections to the Kähler potential outlined in [6], let us turn to analyze other proposals made in the context of the linear multiplet formalism [7,8]. Following the results of Burgess *et al.* [15], we know that both formulations, chiral and linear, must be equivalent and our task is to show it explicitly in this context.

The Kähler potential in the linear multiplet formulation can be expressed as

$$K = \log(l) + g(l), \quad (10)$$

where l is the dilaton field, the lowest component of the vector superfield which parametrizes the gaugino condensate. At tree level, and in the absence of nonperturbative corrections, $g(l) = 0$ in the expression above and, moreover, $1/l = 2\text{Re}S$, recovering the usual tree-level Kähler potential in the chiral formulation. If we include non-perturbative corrections then, as indicated in [8], the relation between l and S changes to

$$\frac{1 + f(l)}{l} = 2\text{Re}S \quad (11)$$

where f is related to g via

$$\frac{dg(l)}{dl} = \frac{f(l)}{l} - \frac{df(l)}{dl} \quad (12)$$

and, from these two equations, we can split Eq. (10) in the same form as Eq. (4), with the non-perturbative part given now by

$$K_{np}(l) = \log[1 + f(l)] + g(l), \quad (13)$$

which can be at least numerically expressed in terms of S by using Eq. (11).

The procedure in Refs. [7,8], once the formalism has been described, is to postulate an *Ansatz* for $f(l)$, in particular we have considered (i) $f(l) = A e^{-B/l}$ [7], and (ii) $f(l) = (A_0 + A_1/\sqrt{l}) e^{-B/\sqrt{l}}$ [8]. The first thing to note is that, in order to obtain an expression for K_{np} , we must first integrate Eq. (12) and, given (i) and (ii), the result is expressed as an exponential-integral function, $E_i(x)$, which always admits an infinite series expansion.

We have reproduced exactly the results of Refs. [7,8] for the shape of the potential and position of the minima in both cases, (i) and (ii). Moreover, we obtain identical results by numerically expressing l in terms of S , through Eq. (11), and using the *chiral* formulation to calculate the scalar potential and its minimum. Both results totally agree proving, at least numerically, the equivalence between both formulations. It is also interesting to note that the shape of these potentials is very much like the one shown in Fig. 2, including the scaling with the gauge group, with the difference that now it is possible to tune the cosmological constant to zero. So it looks like two apparently different formulations and *Ansätze* would lead to potentials with analogous characteristics.

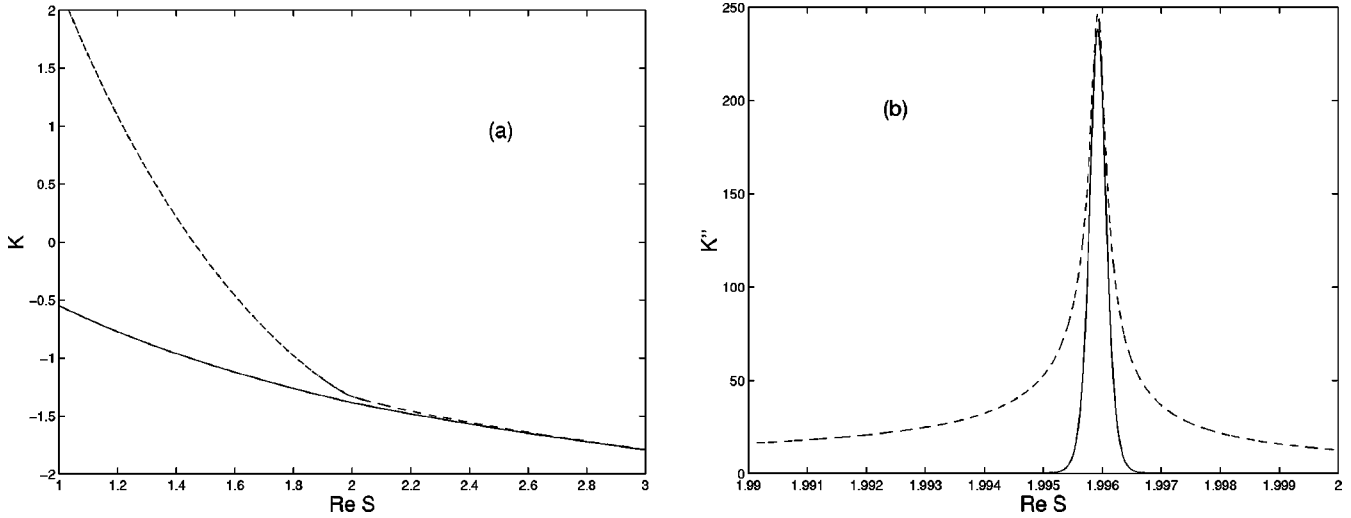


FIG. 3. (a) Plot of the Kähler potential K vs $\text{Re}S$ for one condensate with gauge group E_6 and two matter multiplets. The dashed line represents the original *Ansatz* (i) from Ref. [7], whereas the solid line is the result of using our approximation Eq. (15) for $S_0=2$ and $D=0.35$. $B \sim 30000$ is fixed by the condition of zero cosmological constant once D has been specified; (b) Same as in (a), but this time for K'' vs $\text{Re}S$.

Let us then analyze the form of K_{np} in more detail. First of all, Eq. (13) can be written in terms of S , and after some algebra the result reduces to

$$K_{np}(\text{Re}S) = \int_{\text{Re}S}^{\infty} \frac{f(\text{Re}S')}{\text{Re}S'} d(\text{Re}S'). \quad (14)$$

Again we do not have an analytic expression for $f(\text{Re}S)$, but even if we did, it still does not look clear what kind of relation, if any, there could be between this and Eq. (6).

Alternatively we can analyze the main features of the Kähler potentials obtained in [7,8] and try to find an analytic functional form which may reproduce them. For that purpose it is useful to realize that the examples presented in [7,8] share exactly the same properties, which are depicted in Fig. 3: the Kähler potential, shown in Fig. 3(a) has a ‘kink’ at the point at which the minimum develops, and its second derivative has a sharp maximum exactly at that point, as shown in Fig. 3(b). This is exactly the opposite behavior to that of the examples in the previous section, where the minimum in the potential was due to $K''=0$ near $(\text{Re}S)_{\text{min}}$. It also explains the mechanism to obtain a zero cosmological constant: by adjusting the height of this maximum, the $1/K''$ term in Eq. (3) can have precisely the right magnitude to cancel the $-3|W|^2$ term.

These two very distinctive characteristics can be reproduced with the following *Ansatz* in the chiral formalism:

$$K_{np} = \frac{D}{B\sqrt{\text{Re}S}} \log(1 + e^{-B(\sqrt{\text{Re}S} - \sqrt{S_0})}), \quad (15)$$

that depends on three parameters, S_0 , D , and B , the first of which just determines the value of $\text{Re}S$ at the minimum. Therefore this description is effectively made in terms of only D and B , which are positive numbers. $D > 0$ is imposed to avoid cancellations in K'' , and therefore singularities in the scalar potential, and $B > 0$ ensures the correct asymptotic be-

havior in the weak coupling limit (i.e., $K_{np} \rightarrow 0$ when $\text{Re}S \rightarrow \infty$). From Figs. 3(a), 3(b) we see that our *Ansatz* Eq. (15), represented by the solid lines, reproduces the main features of the non-perturbative corrections proposed in the linear formulation. In particular, we are presenting here the results of the comparison with *Ansatz* (i), but we have also reproduced the main features of (ii). Notice as well that the numerical values of D and B are chosen such as to guarantee a zero cosmological constant, as shown in Fig. 4(a). In order to compare with Eq. (6) it is useful to split Eq. (15) into two different expressions, valid for $\text{Re}S$ bigger/smaller than S_0 . We find

$$e^{K_{np}} = 1 + \frac{D e^{B\sqrt{S_0}}}{B} (\text{Re}S)^{-1/2} e^{-B\sqrt{\text{Re}S}}, \quad \text{Re}S > S_0,$$

$$e^{K_{np}} = e^{-D(\sqrt{\text{Re}S} - \sqrt{S_0})/\sqrt{\text{Re}S}}, \quad \text{Re}S < S_0. \quad (16)$$

Using the previous expressions we can rewrite $e^K = e^{K_0 + K_{np}}$ as $e^K = e^{K_0} + e^{\tilde{K}_{np}}$, where now

$$e^{\tilde{K}_{np}} = \frac{D e^{B\sqrt{S_0}}}{2B} (\text{Re}S)^{-3/2} e^{-B\sqrt{\text{Re}S}}, \quad \text{Re}S > S_0,$$

$$e^{\tilde{K}_{np}} = \frac{1}{2\text{Re}S} [-1 + e^{-D(\sqrt{\text{Re}S} - \sqrt{S_0})/\sqrt{\text{Re}S}}]$$

$$\sim \frac{e^{-D}}{2} (\text{Re}S)^{-1} e^{D\sqrt{S_0}/\sqrt{\text{Re}S}}, \quad \text{Re}S < S_0, \quad (17)$$

making explicit the resemblance of these expressions with that of Eq. (6) in the context of Eq. (5). Note that, in the weak coupling regime (i.e., $\text{Re}S > S_0$), we can make the identifications $d = D e^{B\sqrt{S_0}}/2B$, $p = -3$ and $B = b$. In particular the size of B required to reproduce the linear multiplet results makes d extremely large, and that corresponds precisely to the solution we found in the previous section with a

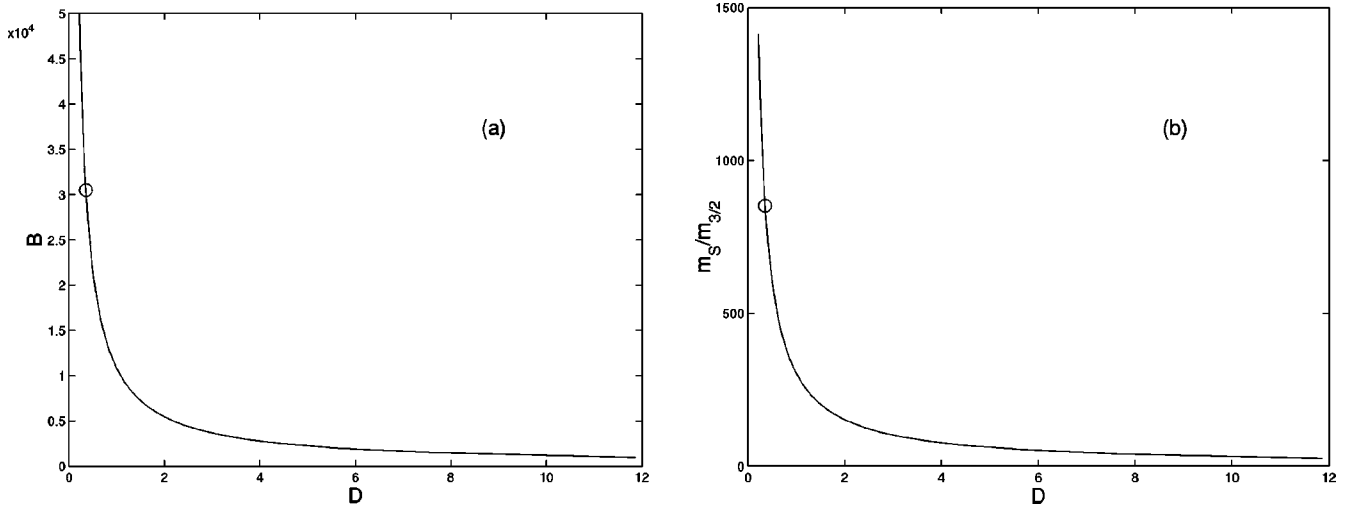


FIG. 4. (a) Values of the B and D parameters (solid line) that give a zero cosmological constant with our *Ansatz* Eq. (15). The circle corresponds to the numbers we use to reproduce the results in Ref. [7]; (b) plot of the ratio between the dilaton and gravitino masses (solid line) versus the parameter D using our *Ansatz* Eq. (15), with $S_0=2$ and B fixed to give zero cosmological constant. The circle corresponds to the result of Ref. [7].

realistic minimum and zero cosmological constant [i.e., Fig. 1(b)]. Therefore we can conclude that the proposals for non-perturbative corrections to the Kähler potential made in the context of the *chiral* [6] and *linear* [7,8] multiplet formalisms essentially correspond to a same functional form evaluated in different regions of parameter space. Let us stress once again that these results are obtained in a tree level approximation to the Kähler potential, that is without the inclusion of Green-Schwarz terms and it would remain to be seen whether they hold once one-loop corrections are taken into account, which is clearly beyond the scope of this article.

One final issue we should address in the context of the linear multiplet formalism is that of the dilaton mass. We saw in the previous section that the vanishing of K'' around the minimum implies an enhancement of the dilaton mass with respect to the gravitino one due to the contribution of factors of $1/K''$ to the former. Now we are dealing with a different situation as K'' has a maximum at the minimum of the potential, therefore we would naively expect some suppression of m_S with respect to $m_{3/2}$.

However this is not true in general, as shown in Fig. 4(b), where we plot the ratio between the dilaton and gravitino masses, $(m_S/m_{3/2})$ versus D , with the corresponding B given by Fig. 4(a). Therefore, in Eq. (7) only the second term contributes, and the coefficient Q is totally dominated by the fourth derivative of the Kähler potential. So the dilaton mass in these models is given by

$$m_S^2 = m_{3/2}^2 \frac{-3K''''}{(K'')^2}. \quad (18)$$

As we can see from Fig. 4(b), the closer D is to zero, the bigger the enhancement factor of m_S with respect to $m_{3/2}$ is, and it can amount to about three orders of magnitude. The circle represents the result when we use the original *Ansatz*

of Ref. [7]. We can obtain with our *Ansatz* bigger values than that, but it implies extremely large values for B , as can be seen in Fig. 4(a).

IV. CONCLUSIONS

We have performed an exhaustive study of the effects of string motivated non-perturbative corrections to the Kähler potential on the phenomenology of superstring derived models. Using previous proposals made in the context of the chiral formulation of gaugino condensation [6] (with the dilaton as part of a chiral supermultiplet), we have fully analyzed the parameter space which they define, and we have shown that a minimum of the scalar potential with a reasonable value for the dilaton and zero cosmological constant can only be achieved for extremely unreasonable values of at least one of the parameters. On the other hand, reasonable values for these give acceptable minima but with positive cosmological constant. In any case, the shape of these potentials does not look very promising as their steepness in the strong coupling regime would prevent the dilaton from settling down at its minimum. However we have shown that the so-called moduli problem gets alleviated, at least in the dilaton sector.

Once we had fully explored these simpler proposals we turned to study the results obtained in the context of the linear multiplet formalism to describe gaugino condensation. We have shown that the *Ansätze* proposed so far in that context can be at least numerically reproduced using the chiral formalism and, moreover, we have proposed an explicit *Ansatz* which essentially reproduces in chiral language the main features of these non-perturbative corrections proposed in [7,8]. To a high degree of accuracy, this *Ansatz* looks very similar to the one initially studied in the chiral formulation, and the corresponding values of the parameters that define them seem to indicate that we are now describing the same type of solutions previously found with zero cosmological

constant. We have shown that both formulations lead to essentially identical results and, in particular, that the results obtained by [6] and [7,8] correspond to basically the same *Ansatz* evaluated in different regions of parameter space. Moreover we are able to reproduce a large hierarchy between the dilaton and gravitino masses, opening up a promising way of solving the usual cosmological problems associated with string-inspired models.

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