New AdS$_4$ vacua in dyonic ISO(7) gauged supergravity

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ABSTRACT: We identify 219 AdS$_4$ solutions in four-dimensional dyonically gauged ISO(7) $\mathcal{N} = 8$ supergravity and present some of their properties. One of the new solutions preserves $\mathcal{N} = 1$ supersymmetry and provides a rare explicit example of an AdS$_4$ vacuum dual to a 3d SCFT with no continuous global symmetry. There are also two new non-supersymmetric solutions for which all 70 scalar fields in the supergravity theory have masses above the BF bound. All of these AdS$_4$ solutions can be uplifted to massive type IIA supergravity. Motivated by this we present the low lying operator spectra of the dual 3d CFTs for all known supersymmetric AdS$_4$ solutions in the theory and organize them into superconformal multiplets.

Contents

1 Introduction and outlook

Charting the terra incognita of consistent AdS$_4$ vacua is a challenging but important task for the explorers of the string theory landscape. A valuable collection of such explicit vacua arises from consistent truncations of 10d or 11d supergravity to four-dimensional gauged supergravity. Our goal in this paper is to describe one such corner of the landscape of AdS$_4$ vacua in massive IIA supergravity [1].

In our search for AdS$_4$ vacua, we explore a 4d $\mathcal{N} = 8$ supergravity theory with a specific dyonic ISO(7) gauging [2, 3]. This theory arises as a consistent truncation of massive type IIA supergravity on S^6 and, in particular, there are explicit uplift formulae that allow to map every 4d solution to a solution in the 10d theory [4]. A notable feature of the 4d gauged supergravity is the non-trivial potential for the 70 scalar fields in the theory. The question of finding interesting AdS$_4$ vacua then translates into finding critical points of this potential. Unfortunately, due to its algebraic complexity, it is hard to compute the potential in closed analytic form.

In this paper, we employ two different methods that have been developed to search for critical points in this context. The first one, proposed by Warner in [5], amounts to imposing invariance under a suitable subgroup of the symmetry group of the supergravity theory. This results in a consistent truncation to a theory with a smaller number of scalar fields in which the scalar potential can be computed and extremized analytically. The

second approach is a full numerical search for the critical points of the scalar potential as a function of all scalar fields. The latter approach has been used in a series of papers to explore the scalar potentials of 3d and 4d maximal gauged supergravity [6–10] and led to the application of machine learning techniques based on Google's `TensorFlow` platform [11] to the 70-scalar potential of the 4d $\mathcal{N} = 8$ de Wit-Nicolai SO(8) gauged supergravity theory [12] in [13] (see, also [14]).[1]

Our approach is effectively a mixture of the two methods.[2] We first identify a suitable $\mathbb{Z}_2 \times \mathbb{Z}_2$ symmetry subgroup and use it to truncate the full 4d $\mathcal{N} = 8$ supergravity to the invariant sector which is 4d $\mathcal{N} = 2$ gauged supergravity with 3 vector multiplets and 4 hypermultiplets. This model has 22 real scalar fields and the supergravity potential can be computed analytically by employing the so-called "solvable parametrization" based on the Iwasawa decomposition of the scalar coset manifold. Unfortunately, the closed form analytic expression for the potential, which we compute explicitly, is quite unwieldy and finding its critical points analytically is still prohibitively difficult. Hence we turn to numerical routines based on `Mathematica` to perform a systematic search for critical points. This results in 219 distinct AdS$_4$ vacua that we find. We have made extensive crosschecks of our results against an ongoing comprehensive search for AdS$_4$ vacua based on Google's `TensorFlow` of the full supergravity potential in (2.14) [19].

There is also a smaller consistent truncation of the dyonically ISO(7) gauged supergravity obtained by imposing an additional $\mathbb{Z}_2$ symmetry, which was considered previously in [20, 24]. It consists of 4d $\mathcal{N} = 1$ supergravity coupled to 7 chiral multiplets. The 14-scalar potential in this truncation can also be studied explicitly and we find that it has 65 of the 219 critical points of the 22-scalar model. Most of these 65 points have been found previously. As summarized in [20], 60 AdS$_4$ vacua have already been found in previous studies of the 14-scalar model and its sub-truncations, see also [21–24]. The net result of our full search is therefore the identification of 159 new critical points of the dyonically gauged ISO(7) supergravity theory.

There are 7 supersymmetric critical points in the full list of 219 points. One of these supersymmetric points is new. In addition, there are 9 non-supersymmetric AdS$_4$ solutions, 2 of which are new, for which all 70 scalars of the 4d $\mathcal{N} = 8$ supergravity have masses above the BF bound [25] and thus are perturbatively stable within the 4d $\mathcal{N} = 8$ theory. We present the spectra of mass fluctuations for all bosonic and fermionic 4d $\mathcal{N} = 8$ supergravity fields around each of these 16 perturbatively stable solutions. For the 7 supersymmetric critical points we organize these spectra into supersymmetric multiplets and map them to the spectrum of operators in the dual 3d SCFT. The new supersymmetric solution is of special interest. It preserves $\mathcal{N} = 1$ supersymmetry and does not exhibit any continuous symmetry. Uplifting this solution to massive IIA supergravity using the formulae in [4] will provide a very rare example of a fully explicit stable AdS$_4$ solution of string theory

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[1]The same techniques were also used in [15, 16] to find AdS$_5$ vacua in the 5d $\mathcal{N} = 8$ SO(6) gauged supergravity.

[2]There is also a third method used to search for AdS$_4$ vacua in gauged supergravity which is based on the embedding tensor formalism, see [17, 18] and references thereof. We do not use this method in the present work.

which does not have any continuous internal symmetry.[3] Using holography, this implies that there is a new 3d $\mathcal{N} = 1$ SCFTs arising on the worldvolume of D2-branes, which has no conserved flavor currents and only a discrete global symmetry.

Our results suggest several directions for further study some of which we would like to mention briefly now before moving on to the technical part of this paper.

It is now clear that the full scalar potential of the 4d $\mathcal{N} = 8$ dyonic ISO(7) supergravity with all 70 scalars should have a very large number of critical points corresponding to a plethora of AdS$_4$ solutions of the theory. Compiling a catalog of these points and their properties will be helpful to better understand the structure of the theory. We plan to report further results in this direction in [19].

The 7 supersymmetric AdS$_4$ solutions that we have identified are necessarily non-perturbatively stable, see [27]. Analyzing the full stability of the 9 non-supersymmetric BF stable solutions that are now known is more subtle. It was shown in [20] that 7 of these solutions, the ones that belong to the 14-scalar model, do not suffer from the Brane-Jet instability discussed in [28]. Similar analysis should be carried out for the 2 new BF stable non-supersymmetric critical points. Even more interesting is to understand the perturbative stability of these points within the massive IIA supergravity using recent methods for computing the Kaluza-Klein mass spectra developed in [29, 30]. Indeed, as shown very recently in [31], one of the previously found non-supersymmetric critical points with a G$_2$ symmetry appears to be stable. It would be interesting to understand what happens with the 2 new non-supersymmetric BF stable points we find here. In view of the AdS Swampland Conjecture [32], one might expect some non-perturbative mechanism triggering an instability that is yet to be found.

Our results should also have implications for the physics of 3d SCFTs arising from D2-branes in massive IIA string theory. The 3d $\mathcal{N} = 8$ SYM theory on the worldvolume of the branes is modified by the presence of a Chern-Simons term induced by the Romans mass. In addition, one can have superpotential mass terms in this theory, which corresponds to turning on background fluxes and metric deformations in the type IIA string theory. Understanding the ensuing RG flows and the low-energy phase diagram of this class of 3d QFTs is in general a complicated problem even when some supersymmetry is preserved. Holography is an indispensable tool to understand this physics. The existence of the 7 supersymmetric AdS$_4$ solutions discussed above suggests that there is a rich web of IR SCFTs connected by RG flows. Some of these RG flows were studied in [22] and the dual CFTs for two of the supersymmetric critical points preserving $\mathcal{N} = 2$ and $\mathcal{N} = 3$ supersymmetry were identified in [21] and [24], respectively. However, to understand the physics of the 3d $\mathcal{N} = 1$ SCFTs dual to the 5 other supersymmetric critical points is far more challenging. This will certainly be the case for the 3d $\mathcal{N} = 1$ SCFT dual to the new AdS$_4$ vacuum that we identify in this paper. Using the spectrum of operators with low conformal dimensions we compute here, together with the $\mathbb{Z}_2 \times \mathbb{Z}_2$ global symmetry, should

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[3]The only other explicit example we are aware of is the AdS$_4$ $\mathcal{N} = 1$ J-fold solution found recently in [26]. To ensure no isometry in the internal space one needs to choose an appropriate Kähler-Einstein manifold for the IIB solution in [26].

facilitate the study of this problem, perhaps by employing the techniques of the $\mathcal{N} = 1$ superconformal bootstrap [33–35].

Finally, we should emphasize that the results of this search exhibit the familiar predicament known from the previous searches (see, e.g., [13, 14, 16]) that most of the critical points in the maximal gauged supergravity theories arising from string and M-theory are non-supersymmetric and BF unstable. As discussed in [36], such instabilities of AdS vacua signal a loss of conformal invariance in the dual QFT. Given that all these unstable AdS solutions arise from string theory and appear to belong to rich webs of interconnected RG flows, it is certainly desirable to understand better their physics and the implications for the dual QFT.

The paper is organized as follows. We continue our discussion in section 2 with a short summary of the salient features of the dyonic ISO(7) gauged supergravity and describe our choice of parametrization of the scalar manifold, delegating some of the details to appendix A. In section 3 we present the result of the numerical search for AdS$_4$ solution in this model. In section 4 we identify the 16 critical points in our list for which all 70 scalar masses obey the BF bound. We also present the mass spectra of the new $\mathcal{N} = 1$ AdS$_4$ solution and the corresponding spectrum of operators in the dual 3d SCFT. In appendix B we present the mass spectra of the 6 other supersymmetric vacua we find in this model and show how to organize the operator dimensions in the dual SCFTs into superconformal multiplets. The mass spectra for the 9 non-supersymmetric BF stable solutions are presented in appendix C.

2 Dyonic ISO(7) gauged supergravity

In this section we give a brief overview of the dyonic ISO(7) gauged supergravity in four dimensions. We focus on the structure of the scalar potential in this model. Further details of the full gauged supergravity theory are given in [3] using the embedding tensor formalism of [37, 38]. As shown in [4, 21], this 4d gauged supergravity arises as a consistent truncation of massive type IIA supergravity [1] on S^6 .

The 70 scalar fields of $\mathcal{N} = 8$ supergravity in four dimensions parametrize the coset manifold $\mathrm{E}_{7(7)}/(\mathrm{SU}(8)/\mathbb{Z}_2)$. To obtain the scalar potential in the theory we need to calculate the vielbein $\mathcal{V}$ on the coset that depends on the 70 scalar fields. We start by constructing the 133 basis elements of $\mathfrak{e}_{7(7)}$ written as 56×56 matrices. We use the real $\mathfrak{sl}(8)$ basis for $\mathfrak{e}_{7(7)}$ (see for example [39]) where the infinitesimal transformation acts on a pair of 28-dimensional vectors written as antisymmetric tensors $x_{[AB]}$ and $x^{[AB]}$ with $A, B = 1, \cdots, 8$. These tensors can be combined into a single **56**-vector $x_{\mathbb{M}} = (x_{[AB]}, x^{[AB]})$

$$
\begin{aligned}
\delta x_{[AB]} &= \Lambda_A{}^C x_{[CB]} + \Lambda_B{}^C x_{[AC]} + \Sigma_{ABCD} x^{[CD]} \,, \\
\delta x^{[AB]} &= -\Lambda_C{}^A x^{[CB]} - \Lambda_C{}^B x^{[AC]} + \Sigma^{ABCD} x_{[CD]} \,.
\end{aligned}
\tag{2.1}
$$

Here $\Lambda_A{}^B$ is a traceless $\mathfrak{sl}(8)$ matrix, Σ_{ABCD} is totally antisymmetric, and Σ^{ABCD} is its dual

$$
\Sigma^{ABCD} = \frac{1}{4!} \epsilon^{ABCDEFGH} \Sigma_{EFGH} \,.
\tag{2.2}
$$

The transformation parameters in (2.1) have been split into $(\Lambda^A{}_B, \Sigma_{ABCD})$ according to the branching rule $\mathbf{133} = \mathbf{63} \oplus \mathbf{70}$ of the adjoint representation of $\mathrm{E}_{7(7)}$ under $\mathrm{SL}(8,\mathbb{R})$. This can be used to write a general element of $\mathfrak{e}_{7(7)}$ as

$$\mathfrak{X}_{\mathbb{M}}{}^{\mathbb{N}} = \begin{pmatrix} 2\Lambda_{[A}{}^{[C}\delta_{B]}^{D]} & \Sigma_{[AB][CD]} \\ \Sigma^{[AB][CD]} & -2\Lambda_{[C}{}^{[A}\delta_{D]}^{B]} \end{pmatrix}. \tag{2.3}$$

One then finds the following result for the $\mathfrak{e}_{7(7)}$ Killing form

$$\mathrm{Tr}\,(\mathfrak{X}_1 \cdot \mathfrak{X}_2) = 12\mathrm{Tr}\,(\Lambda_1 \cdot \Lambda_2) + 2\Sigma_{1\,ABCD}\Sigma_2^{ABCD}. \tag{2.4}$$

In particular, this shows that the 70 non-compact generators are obtained by selecting Λ symmetric and Σ_{ABCD} self-dual. The 63 remaining generators are obtained by specifying Λ antisymmetric and Σ_{ABCD} anti-self-dual form the $\mathfrak{su}(8)$ subalgebra of $\mathfrak{e}_{7(7)}$.

We will work in a basis of generator for $\mathfrak{e}_{7(7)}$ obtained by choosing a suitable basis for $\Lambda^A{}_B$ and Σ_{ABCD}, namely

$$t_A{}^B: \qquad \Lambda_C{}^D = \frac{1}{\sqrt{2}}\delta_C^B\delta_A^D, \qquad\qquad \Sigma = 0,$$
$$t_{ABCD}: \quad \Sigma_{EFGH} = \frac{1}{2\sqrt{2}}\epsilon_{ABCDEFGH}, \quad \Lambda = 0, \tag{2.5}$$

where the normalization coefficients have been chosen for convenience. Notice that the diagonal $t_A{}^B$ generators do not correspond to traceless Λ. Indeed we have eight $t_A{}^A$ which should always be combined in such a way so that the trace is removed. We will come back to this below.

2.1 Solvable parametrization

After defining a basis for the generators $\mathrm{E}_{7(7)}$ we are ready to discuss the parametrization of the scalar manifold. We employ the so-called solvable parametrization [40, 41], in which the scalar vielbein is given by

$$\mathcal{V} = \exp\left(\varphi_n \mathfrak{h}_n\right) \cdot \exp\left(\sum_{\alpha \in \Delta_+} \theta_\alpha \mathfrak{e}_\alpha\right), \tag{2.6}$$

where $\mathfrak{h}_i$ are the generators of a noncompact Cartan subalgebra and $\mathfrak{e}_\alpha$ are generators of a nilpotent subalgebra corresponding to positive root generators. This parametrization has several advantages; firstly the exponents are relatively simple to compute, and secondly the truncation with respect to discrete symmetries discussed below is straightforward.

To proceed we select a noncompact Cartan subalgebra defined by a combination of diagonal generators in $\mathfrak{sl}(8,\mathbb{R})$. We need to combine them appropriately to obtain a proper traceless $\mathfrak{sl}(8,\mathbb{R})$ matrix as discussed above. This results in seven Cartan generators given by

$$\mathfrak{h}_n = \frac{1}{\sqrt{n(n+1)}}\left(\sum_{i=1}^n t_i{}^i - n\,t_{n+1}{}^{n+1}\right), \qquad n = 1, \ldots 7. \tag{2.7}$$

The corresponding positive and negative root generators, $\mathfrak{e}_\alpha$ and $\mathfrak{f}_\alpha$, respectively, are given in table 4 in appendix A. They obey the following identities

$$[\mathfrak{h}_n, \mathfrak{e}_\alpha] = \alpha_n \mathfrak{e}_\alpha \,, \qquad [\mathfrak{h}_n, \mathfrak{f}_\alpha] = -\alpha_n \mathfrak{f}_\alpha \,. \tag{2.8}$$

We parametrize the positive roots, $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \ldots, \alpha_7) \in \Delta_+$, in terms of their coordinates in the simple root basis,

$$[n_1 n_2 n_3 n_4 n_5 n_6 n_7] \qquad \longleftrightarrow \qquad \boldsymbol{\alpha} = \sum_{i=1}^{7} n_i \boldsymbol{\alpha}_{(i)} \,, \tag{2.9}$$

where the simple roots, $\boldsymbol{\alpha}_{(i)}$, are given explicitly by

$$\boldsymbol{\alpha}_{(1)} = \left(\sqrt{2}, 0, 0, 0, 0, 0, 0 \right) \,, \qquad\qquad \boldsymbol{\alpha}_{(2)} = \left(-\frac{1}{\sqrt{2}}, \sqrt{\frac{3}{2}}, 0, 0, 0, 0, 0 \right) \,,$$

$$\boldsymbol{\alpha}_{(3)} = \left(0, -\sqrt{\frac{2}{3}}, \frac{2}{\sqrt{3}}, 0, 0, 0, 0 \right) \,, \qquad\qquad \boldsymbol{\alpha}_{(4)} = \left(0, 0, -\frac{\sqrt{3}}{2}, \frac{\sqrt{5}}{2}, 0, 0, 0 \right) \,,$$

$$\boldsymbol{\alpha}_{(5)} = \left(0, 0, 0, -\frac{2}{\sqrt{5}}, \sqrt{\frac{6}{5}}, 0, 0 \right) \,, \qquad\qquad \boldsymbol{\alpha}_{(6)} = \left(0, 0, 0, 0, -\sqrt{\frac{5}{6}}, \sqrt{\frac{7}{6}}, 0 \right) \,,$$

$$\boldsymbol{\alpha}_{(7)} = \left(0, 0, 0, -\frac{2}{\sqrt{5}}, -\sqrt{\frac{8}{15}}, -\sqrt{\frac{8}{21}}, -\sqrt{\frac{2}{7}} \right) \,. \tag{2.10}$$

The normalization above are chosen such that

$$\text{Tr } \mathfrak{h}_m \mathfrak{h}_n = 12 \, \delta_{mn} \,, \qquad \text{Tr } \mathfrak{e}_\alpha \mathfrak{e}_\beta = \text{Tr } \mathfrak{f}_\alpha \mathfrak{f}_\beta = 0 \,, \qquad \text{Tr } \mathfrak{e}_\alpha \mathfrak{f}_\beta = 6 \, \delta_{\alpha\beta} \,. \tag{2.11}$$

2.2 The scalar potential

With the coset parametrization at hand we move on to some of the relevant details of the supergravity theory. We are interested in searching for AdS$_4$ vacua and thus we need to study the critical points of the scalar potential V. To this end we focus on the scalar part of the supergravity Lagrangian which reads

$$\mathcal{L} = \sqrt{-g} \left(R + \frac{1}{96} D_\mu \mathcal{M}^{\mathbb{M}\mathbb{N}} D^\mu \mathcal{M}_{\mathbb{M}\mathbb{N}} - V \right) \,, \tag{2.12}$$

where

$$\mathcal{M} = \mathcal{V} \cdot \mathcal{V}^T \,, \quad \mathcal{M}^{\mathbb{M}\mathbb{R}} \mathcal{M}_{\mathbb{R}\mathbb{N}} = \delta_{\mathbb{N}}^{\mathbb{M}} \,, \tag{2.13}$$

and D_μ is the gauge covariant derivative. The scalar potential is given by [3, 38]

$$V = \frac{g^2}{672} \mathcal{M}^{\mathbb{M}\mathbb{P}} X_{\mathbb{M}\mathbb{N}}{}^{\mathbb{R}} X_{\mathbb{P}\mathbb{Q}}{}^{\mathbb{S}} \left(\mathcal{M}^{\mathbb{N}\mathbb{Q}} \mathcal{M}_{\mathbb{R}\mathbb{S}} + 7 \delta_{\mathbb{S}}^{\mathbb{N}} \delta_{\mathbb{R}}^{\mathbb{Q}} \right) \,, \tag{2.14}$$

where g is the gauge coupling constant. For the ISO(7) gauging of the $\mathcal{N} = 8$ theory the tensor X can be obtained from the embedding tensor specifying the gauging and is given by [3]

$$X_{[AB][CD]}{}^{[EF]} = -X_{[AB]}{}^{[EF]}{}_{[CD]} = -8 \delta_{[A}^{[E} \theta_{B][C} \delta_{D]}^{F]} \,,$$

$$X^{[AB]}{}_{[CD]}{}^{[EF]} = -X^{[AB][EF]}{}_{[CD]} = -8 \delta_{[C}^{[A} \xi^{B][E} \delta_{D]}^{F]} \,, \tag{2.15}$$

where

$$\theta = \text{diag}(1,1,1,1,1,1,1,0)\,, \qquad \xi = \text{diag}(0,0,0,0,0,0,0,c)\,. \qquad (2.16)$$

The parameter c characterizes the type of ISO(7) gauging. It was shown in [2] that there are two inequivalent gaugings. For $c = 0$ the gauging is purely electric and one recovers the ISO(7) gauged supergravity theory constructed by Hull in [42]. This 4d $\mathcal{N} = 8$ theory arises as a consistent truncation of the type IIA supergravity with vanishing Romans mass on S^6. For $c \neq 0$ the seven translations inside ISO(7) are dyonically gauged with a coupling constant $m = gc$. As discussed in [2] for all values of $c \neq 0$ the theory is equivalent and can be obtained by a consistent truncation of the massive IIA supergravity on S^6 [4, 21].[4] From now on we work in conventions where we set $c = 1$ and also set the parameter $g = 1$ which in turn fixes the AdS$_4$ length scale.

2.3 Discrete symmetries and truncations

Since the full scalar potential is difficult to compute as a function of the 70 scalar fields, we focus on truncations using three $\mathbb{Z}_2 \subset \text{SL}(8,\mathbb{R})$ symmetries that act on an eight-dimensional vector as follows [24]:

$$S_1 : (x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8) \mapsto (x_1, x_2, x_3, -x_4, -x_5, -x_6, -x_7, x_8)\,,$$
$$S_2 : (x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8) \mapsto (x_1, -x_2, -x_3, x_4, x_5, -x_6, -x_7, x_8)\,, \qquad (2.17)$$
$$S_3 : (x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8) \mapsto (x_1, -x_2, x_3, -x_4, x_5, -x_6, x_7, -x_8)\,.$$

One can impose invariance under these $\mathbb{Z}_2$ symmetries in order to construct consistent truncations of the 4d $\mathcal{N} = 8$ gauged supergravity. Three inequivalent truncation may be obtained by keeping fields invariant under one, two, or all three actions. We now proceed to discuss three different truncations obtained in this way.

Keeping the supergravity fields that are invariant under one of the three discrete symmetries in (2.17), say S_1, results in an $\mathcal{N} = 4$ supergravity theory, see [23, 43]. The invariant fields include the metric as well as 38 real scalars that parametrize the manifold

$$\frac{\text{SO}(6,6)}{\text{SO}(6) \times \text{SO}(6)} \times \frac{\text{SL}(2,\mathbb{R})}{\text{U}(1)}\,. \qquad (2.18)$$

In addition, one finds 12 invariant vector fields that transform in the adjoint of $\text{SO}(4) \times \text{ISO}(3)$. The invariant fermions comprise of 4 gravitini and 28 gaugini. These fields can indeed be organized into an $\mathcal{N} = 4$ gravity multiplet and 6 vector multiplets to form a full $\mathcal{N} = 4$ supergravity theory, see for instance [44]. Unfortunately it is prohibitively hard to compute explicitly the potential in this truncation analytically.

A more tractable truncation can be obtained by imposing invariance with respect to two of the three $\mathbb{Z}_2$ actions (2.17), say S_1 and S_2. The invariant fields consist of the metric together with 22 real scalar fields parametrizing the manifold

$$\frac{\text{SO}(4,4)}{\text{SO}(4) \times \text{SO}(4)} \times \left[\frac{\text{SL}(2,\mathbb{R})}{\text{U}(1)}\right]^3\,. \qquad (2.19)$$

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[4]The parameter m is proportional to the Romans mass in the massive IIA supergravity.

In addition one also finds that $O(1,1) \times SO(2)^3$ gauge fields, 2 gravitini and 14 gaugini are left invariant. These fields can be organized into a full 4d $\mathcal{N} = 2$ supergravity theory consisting of the $\mathcal{N} = 2$ gravity multiplet coupled to 3 vector multiplets and 4 hypermultiplets. We were able to find an analytic expression for the scalar potential in this model and in the next section we perform a systematic search and find 219 critical points. Since the generators S_1 and S_2 generate the discrete group $\mathbb{Z}_2 \times \mathbb{Z}_2$ (which is isomorphic to the Klein four-group), all 219 critical points of this truncation exhibit at least $\mathbb{Z}_2 \times \mathbb{Z}_2$ symmetry.

Yet another consistent truncation can be found by imposing invariance with respect to all three discrete symmetries in (2.17). The result is a theory with 14 real scalar fields parametrizing the manifold

$$\left[\frac{\mathrm{SL}(2, \mathbb{R})}{\mathrm{U}(1)} \right]^7. \tag{2.20}$$

The truncation also includes the metric, one gravitino, and seven gaugini. This can be formulated as an $\mathcal{N} = 1$ supergravity coupled to 7 chiral multiplets and the potential of this model can be computed analytically in terms of a simple superpotential. This truncation was previously studied in [20, 24] where 60 critical points were found. Our search has identified 5 new critical points in this truncation all of which are non-supersymmetric and perturbatively unstable. A very similar truncation in the SO(8) gauged supergravity was identified and studied in [14] and it was shown to contain 48 critical points.

In table 4 we indicate all root generators that are left invariant in the three truncations summarized above. The seven Cartan generators in (2.7) are all invariant under S_1, S_2, and S_3.

3 Numerical search for AdS$_4$ vacua

We now focus on studying the critical points of the potential in the 22-scalar model (2.19). The potential for this model can be computed analytically with the help of `Mathematica` using the solvable parametrization described in section 2.1. The explicit expression for the potential is unwieldy and will not be presented here. It can be found in the supplementary material `PotentialAndCriticalPoints.txt`. A notable feature of the potential is that it is a function of only 21 of the 22 real scalars in (2.19). This is due to an unbroken noncompact symmetry of the potential in this truncation.

To find the critical points of this potential we resort to numerical techniques. We have employed numerical `Mathematica` code which uses the explicit analytic form of the potential and its derivatives in combination with the built-in `FindRoot[·]` routine. After extensive automated searches using this code we have identified 219 distinct critical points.[5]

To present our results, we use the notation P`nnnnnn` to label a critical point for which the potential evaluates to the numerical value $V = -nn.nnnnn\dots$. Note that these labels are *not* constructed from rounded values of the potential, but rather from the truncated ones. The full list of 219 critical points of the 22 scalar model can be found in table 1. We

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[5]A comprehensive `TensorFlow` search for AdS$_4$ vacua, together with their mass spectra, of the full supergravity potential in (2.14) will be presented in [19].

have also performed a systematic numerical search for critical points of the 14-scalar model in (2.20). We have identified 65 critical points which are identified with a $*$ in table 1. We note that the 14-scalar model, and some of its smaller sub-truncations, have been studied before in the literature and as summarized in [20] 60 critical points have been identified. Our list of 65 critical points of the 14-scalar model contains all these 60 critical points.

Some comments are in order. There are two vacua in the full list, both of them previously identified, that have exactly the same value of the potential $V = -2^{16/3}/3^{1/2}$ but are distinct physical solutions. The critical point P23277304$_1$ has $\mathcal{N} = 3$ supersymmetry and $\mathrm{SO}(3) \times \mathrm{SO}(3)$ invariance while P23277304$_2$ is non-supersymmetric and has G$_2$ invariance. A pair of new AdS$_4$ solutions also deserves special attention. The critical point P355983405 preserves $\mathcal{N} = 1$ supersymmetry and no continuous global symmetry. The critical point P355983403 is non-supersymmetric, but BF stable, and also does not have a continuous global symmetry. While the first 8 digits in the value of V for these two critical points are identical, we have checked with high precision that they are not the same critical point. The potential for P355983405 can be computed in a closed algebraic form and is given by $V = -2^{22/3} \times 7^{7/6}/(3 \times 5^{5/3})$, while we have not been able to find a similar expression for P355983403.

For the 219 critical points in table 1 we have calculated the mass spectra of all bosonic and fermionic fields of the 4d $\mathcal{N} = 8$ supergravity theory. We find that 16 of these AdS$_4$ solutions do not exhibit BF instabilities. We discuss these critical points in more detail in the next section.

4 New BF stable AdS$_4$ vacua

From the list of 16 BF stable critical points we find that only 3 are new. The other 13 perturbatively stable AdS$_4$ solutions lie in the 14-scalar model and have already been given in [20]. Two of the new stable solutions, P355983403 and P23715872, are non-supersymmetric while P355983405 has $\mathcal{N} = 1$ supersymmetry. In table 2 we summarize the 16 stable solutions together with the continuous global symmetry and supersymmetry they preserve. We also provide references to the original literature where the 13 known solutions have been discussed.

In appendix B we present the full 4d $\mathcal{N} = 8$ supergravity mass spectra of the 6 previously known supersymmetric points in table 2. In addition we translate this data into information about operator dimension in the dual SCFTs and organize the operators into superconformal multiplets.[6] In appendix C we similarly give the full four-dimensional mass spectra for all 9 non-supersymmetric in table 2 points including the 2 new points P355983403 and P23715872. In the supplementary material `PotentialAndCriticalPoints.txt` we give the mass spectrum for all 219 critical points. We now focus on discussing in more detail the new $\mathcal{N} = 1$ AdS$_4$ critical point P355983405.

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[6]Part of this information was either missing from the previous literature or can be found scattered in different references so we found it useful to collect it in one place.

P19614907*	P19987059*	P20784609*	P21381569*	P21867393*	P23277304$_1^*$	P23277304$_2^*$	P23322349*
P23413628*	P23456052*	P23456098*	P23456778*	P23458779*	P23512689*	P23715872	P23795609*
P23922493	P23924535	P23952870*	P24096811*	P24149894	P24149896*	P24318391*	P24402661
P24533178*	P24691009*	P24692967*	P24701527	P25111949*	P25693378*	P25697101*	P25921891
P25947132*	P26884247	P27101435*	P27102980	P27133412	P27136806*	P27141718	P27162703
P27311529	P27360665	P27418225*	P27450050	P27609962*	P27938983	P27966612	P28050399*
P28124657	P28197845*	P28210030	P28486631*	P28981494	P29178187	P29218859	P29353962*
P29695104	P29773063	P29781636	P29782487*	P29984782	P30083578	P30116288	P30241973*
P30249480	P30291641	P30324163*	P30380484	P30381567	P30384816	P30417814*	P30434903*
P30436799	P30680917	P30700546	P30861770	P30867190	P30880584*	P31016284	P31040481*
P31195012*	P31283092	P31334051*	P31364826	P31696817	P31754742	P31769077	P31815423
P31871366	P31873079	P32083785	P32186031	P32219540*	P32253565	P32254273	P32390058
P32416513	P32628020	P32634842	P32784544	P32816897*	P32859039	P32874514	P32919810
P32919845	P33042513*	P33076426	P33093136	P33180785*	P33181501*	P33184214*	P33599474*
P34064075	P34215811	P34478026	P34757437*	P34768017*	P34778237	P34796796*	P35001597*
P35076002	P35596894	P35598271	P355983403	P355983405	P35610181*	P35610224*	P35610235*
P35651026	P35698097	P35919737	P35990424	P36054725	P36055521*	P36067554	P36072686*
P36092714	P36100336	P36144034	P36228968	P36234552	P36329784	P36944902	P37258768
P38153176	P38539173*	P38606422	P38724006	P38724625*	P38769482	P38824768	P38858068
P39197231	P39648336	P39744741	P39761278*	P39765598	P39794481	P40592093	P40600932*
P40763269	P41049034	P41318714	P41432947	P41710023	P41965792	P41991457	P42230669*
P42232971	P42595364	P43225067	P43479441	P43610159	P44397048	P44625246	P44629770
P44636365	P44662466	P47020437	P47058875	P47578177	P48095682	P48096325	P48141929
P48619344	P49599127	P49797271	P50309909	P52385281	P52557082	P53423001	P53547629*
P54934580	P55416647	P56156622	P58641723	P58768917	P59496572	P59571914	P59603188
P60664200	P61221291	P61898524*	P62135276	P62783730	P63130245	P63227985	P63266652
P63955920	P64764264	P65136976	P65632203	P65991426	P66058194	P71032966	P71983709
P76604976	P85310001	P85678094					

Table 1. All 219 critical points of the 22-scalar model. The 65 critical points marked with * are also critical points of the 14-scalar model.

4.1 Supergravity mass spectra for P355983405

The new $\mathcal{N} = 1$ AdS$_4$ solution P355983405 has the following algebraic value of the potential

$$V = -\frac{2^{22/3} \times 7^{7/6}}{3 \times 5^{5/3}} \, . \tag{4.1}$$

We arrived at this algebraic expression by comparing it to the numerical value determined by our numerical codes with an accuracy of more than 300 digits. The constant values of the scalars fields which specify the location of the critical point on the scalar manifold can be found in the supplementary material PotentialAndCriticalPoints.txt. It should be noted that in the solvable parametrization of the scalar coset described above the location of the critical point is determined by 17 non-trivial values for the 22 scalar fields in (2.19). To determine some of the properties of this critical point it is instructive to calculate the

Point	SUSY	Cont. symmetry	V	Reference
P19987059	$\mathcal{N}=1$	G_2	$-\frac{2^{28/3}\times 3^{1/2}}{5^{5/2}}$	[45–47]
P20784609	$\mathcal{N}=2$	$\mathrm{SU}(3)\times \mathrm{U}(1)$	$-2^2\times 3^{3/2}$	[21]
P23277304$_1$	$\mathcal{N}=3$	$\mathrm{SO}(3)\times \mathrm{SO}(3)$	$-\frac{2^{16/3}}{3^{1/2}}$	[48]
P23795609	$\mathcal{N}=1$	$\mathrm{SU}(3)$	$-\frac{2^8\times 3^{3/2}}{5^{5/2}}$	[3]
P25697101	$\mathcal{N}=1$	$\mathrm{U}(1)$	-25.697101	[24]
P355983405	$\mathcal{N}=1$	$\emptyset$	$-\frac{2^{22/3}\times 7^{7/6}}{3\times 5^{5/3}}$	Here
P35610235	$\mathcal{N}=1$	$\mathrm{U}(1)$	-35.610235	[24]
P23277304$_2$	$\mathcal{N}=0$	G_2	$-\frac{2^{16/3}}{3^{1/2}}$	[46, 47, 49]
P23413628	$\mathcal{N}=0$	$\mathrm{SU}(3)$	-23.413628	[3]
P23456052	$\mathcal{N}=0$	$\mathrm{SO}(3)\times \mathrm{U}(1)$	-23.456053	[23]
P23456098	$\mathcal{N}=0$	$\mathrm{SO}(3)$	-23.456098	[23]
P23456778	$\mathcal{N}=0$	$\mathrm{SU}(3)$	-23.456779	[3]
P23458779	$\mathcal{N}=0$	$\mathrm{SO}(3)\times \mathrm{U}(1)$	-23.458780	[23]
P23512689	$\mathcal{N}=0$	$\mathrm{SO}(3)\times \mathrm{SO}(3)$	-23.512690	[3]
P23715872	$\mathcal{N}=0$	$\mathrm{U}(1)$	-23.715872	Here
P355983403	$\mathcal{N}=0$	$\emptyset$	-35.5983403	Here

Table 2. All known BF stable AdS_4 solutions in the 22-scalar truncation (2.19) including the new solutions P355983403, P355983405, and P23715872.

masses for the linearized perturbation of bosonic and fermionic fields in the 4d $\mathcal{N}=8$ supergravity theory. To this end we have used the mass formulae summarized in [48] and computed the mass spectra numerically to a high degree of accuracy. For clarity, below we present only the first 7 digits for each mass. We use the subscripts ψ, A, χ, and ϕ to denote the 8 gravitini, 28 spin-1 fields, 56 spin-1/2 fields, and the 70 scalars in the 4d $\mathcal{N}=8$ supergravity, respectively. To indicate the degeneracy, n, of each of the modes we use a subscript $_{\times n}$ next to the numerical value of the mass. We then find the following values for the dimensionless squared masses $m^2 L^2$ for the P355983405 critical point[7]

$$m_\psi^2 L^2 : 5.02803_{\times 1},\ 4.89758_{\times 1},\ 3.25582_{\times 1},\ 3.14936_{\times 1},\ 2.75003_{\times 1},$$
$$2.57143_{\times 1},\ 2.41918_{\times 1},\ 1_{\times 1},$$
$$m_A^2 L^2 : 7.27036_{\times 1},\ 7.19910_{\times 1},\ 7.11063_{\times 1},\ 6.95606_{\times 1},\ 6.35686_{\times 1},$$
$$5.97573_{\times 1},\ 5.78845_{\times 1},\ 5.67796_{\times 1},\ 5.21669_{\times 1},\ 5.06021_{\times 1},$$
$$4.92400_{\times 1},\ 4.73855_{\times 1},\ 4.40835_{\times 1},\ 4.27033_{\times 1},\ 4.17500_{\times 1},$$
$$3.97455_{\times 1},\ 2.78570_{\times 1},\ 2.68453_{\times 1},\ 1.45143_{\times 1},\ 1.37472_{\times 1},$$
$$1.09171_{\times 1},\ 0.967861_{\times 1},\ 0.863807_{\times 1},\ 0.672028_{\times 1},\ 0.668804_{\times 1},$$
$$0.394356_{\times 1},\ 0.367529_{\times 1},\ 0.00325020_{\times 1},$$

---

[7]We use conventions in which the AdS_4 length scale, L, is related to the potential as $V = -6/L^2$.

$$m_\chi^2 L^2 : 20.1121_{\times 1},\ 19.5903_{\times 1},\ 13.0233_{\times 1},\ 12.5974_{\times 1},\ 11.0001_{\times 1},$$
$$10.4284_{\times 1},\ 10.2857_{\times 1},\ 10.1405_{\times 1},\ 9.87480_{\times 1},\ 9.67671_{\times 1},$$
$$9.42724_{\times 1},\ 9.42510_{\times 1},\ 8.97087_{\times 1},\ 8.74578_{\times 1},\ 8.74207_{\times 1},$$
$$8.61270_{\times 1},\ 8.05479_{\times 1},\ 7.62328_{\times 1},\ 7.47206_{\times 1},\ 7.36171_{\times 1},$$
$$7.01399_{\times 1},\ 6.89643_{\times 1},\ 5.02803_{\times 1},\ 4.96980_{\times 1},\ 4.89758_{\times 1},$$
$$4.77165_{\times 1},\ 4.28648_{\times 1},\ 4.24572_{\times 1},\ 4.22499_{\times 1},\ 4.00432_{\times 1},$$
$$3.98059_{\times 1},\ 3.83113_{\times 1},\ 3.74322_{\times 1},\ 3.37860_{\times 1},\ 3.25582_{\times 1},$$
$$3.14936_{\times 1},\ 3.00505_{\times 1},\ 2.75003_{\times 1},\ 2.64422_{\times 1},\ 2.57143_{\times 1},$$
$$2.41918_{\times 1},\ 2.13225_{\times 1},\ 2.12735_{\times 1},\ 1.69707_{\times 1},\ 1.65336_{\times 1},$$
$$1.00649_{\times 1},\ 0.866994_{\times 1},\ 0.283967_{\times 1},\ 0.275774_{\times 1},\ 0.274515_{\times 1},$$
$$0.211805_{\times 1},\ 0.210261_{\times 1},\ 0.139918_{\times 1},\ 0.0916383_{\times 1},\ 0.0816989_{\times 1},$$
$$0.0000105000_{\times 1},$$

$$m_\phi^2 L^2 : 11.0172_{\times 1},\ 10.4951_{\times 1},\ 9.69877_{\times 1},\ 8.38431_{\times 1},\ 8.07495_{\times 1},$$
$$7.66239_{\times 1},\ 5.19910_{\times 1},\ 4.95606_{\times 1},\ 4.73238_{\times 1},\ 4.35686_{\times 1},$$
$$4.35507_{\times 1},\ 4.30623_{\times 1},\ 4.28046_{\times 1},\ 4.00540_{\times 1},\ 3.97573_{\times 1},$$
$$3.78845_{\times 1},\ 3.78537_{\times 1},\ 3.67796_{\times 1},\ 3.21669_{\times 1},\ 2.86225_{\times 1},$$
$$2.73855_{\times 1},\ 2.64846_{\times 1},\ 2.36560_{\times 1},\ 2.27033_{\times 1},\ 0.185203_{\times 1},$$
$$0.169510_{\times 1},\ 0.00324116_{\times 1},\ 0_{\times 28},\ -0.201881_{\times 1},\ -1.18315_{\times 1},$$
$$-1.19908_{\times 1},\ -1.20154_{\times 1},\ -1.32797_{\times 1},\ -1.33120_{\times 1},\ -1.48603_{\times 1},$$
$$-1.60564_{\times 1},\ -1.63247_{\times 1},\ -1.99675_{\times 1},\ -2.06413_{\times 1},\ -2.23414_{\times 1},$$
$$-2.24892_{\times 1},\ -2.24937_{\times 1},\ -2.24943_{\times 1},$$

From the gravitino mass spectrum we read of that there is one spin-3/2 mode of mass $m_\psi^2 L^2 = 1$ corresponding to the preserved $\mathcal{N} = 1$ supersymmetry. The critical point is invariant under the $\mathbb{Z}_2 \times \mathbb{Z}_2$ symmetry used to specify the truncation in (2.19). There is no continuous symmetry since there are no massless spin-1 modes in the spectrum. This implies that the ISO(7) gauge symmetry of the 4d $\mathcal{N} = 8$ supergravity is completely broken. This is further supported by the fact that there are 28 massless Goldstone scalars.

4.2 3d $\mathcal{N} = 1$ CFT spectrum for `P355983405`

The `P355983405` AdS$_4$ solution can be consistently embedded in type IIA string theory and thus should have a well-defined 3d $\mathcal{N} = 1$ SCFT as a holographic dual. This should be a strongly coupled CFT with no continuous global symmetry and a minimal amount of supersymmetry, which makes it hard to study with conventional QFT techniques. Therefore it is valuable to use the AdS/CFT dictionary and the mass spectra computed above to calculate the spectrum of low-dimensional operators in this theory. The formulae relating supergravity masses to conformal dimensions for operators of different spin are summarized in table 3. The spectrum of operator dimensions can then be organized into multiplets of the 3d $\mathcal{N} = 1$ superconformal algebra.

Spin	Dimension
0	$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} + m^2 L^2}$
$\frac{1}{2}$	$\Delta = \frac{3}{2} + |mL|$
1	$\Delta = \frac{3}{2} \pm \sqrt{\frac{1}{4} + m^2 L^2}$
$\frac{3}{2}$	$\Delta = \frac{3}{2} + |mL|$

Table 3. Conformal dimensions of CFT operators dual to supergravity fields of spin, s, and mass, m.

Before we present the results of this calculation we comment on some general features.[8] Some of the modes in the full spectrum of quadratic fluctuations do not correspond to CFT operators since they are "eaten" by the usual (super-)Higgs mechanism. In particular, if the ISO(7) gauge symmetry of the 4d $\mathcal{N} = 8$ supergravity is broken to a subgroup $\mathfrak{g}$ in a given AdS$_4$ vacuum, then the number of massless spin-0 modes that combine with the massive vectors is $28 - \dim \mathfrak{g}$. Similarly, for each massive gravitino with mass $m_\psi^2 L^2 > 1$ a spin-1/2 fermion with mass $m_\chi^2 = 4m_\psi^2$ is eaten. For the solution P355983405 there is no continuous symmetry left and thus 28 massless scalars and seven massive spin-1/2 fermions are taken by the Higgs mechanism. Only after removing these Goldstone modes from the mass spectrum one should apply the formulae in table 3 to determine the SCFT operator spectrum. Furthermore, when computing the dimensions of operators dual to spin-1 and spin-0 modes we must be careful to choose the appropriate signs in the formulae in table 3 such that the unitarity bound is obeyed. For some of the scalar modes two possible dimensions are compatible with the unitarity bound and one has a choice of alternate quantization, see [50]. This choice is unambiguously fixed by organizing the operator spectrum into $\mathcal{N} = 1$ CFT multiplets.

There are two types of long and one type of short 3d $\mathcal{N} = 1$ superconformal multiplets we encounter. They will be denoted as follows[9]

$$\text{Short}[s > 0] = \left\{ |s + 1, s\rangle, |s + \frac{3}{2}, s + \frac{1}{2}\rangle \right\},$$

$$\text{Long}[\Delta, 0] = \left\{ |\Delta, 0\rangle, |\Delta + \frac{1}{2}, \frac{1}{2}\rangle, |\Delta + 1, 0\rangle \right\}, \tag{4.2}$$

$$\text{Long}[\Delta, s > 0] = \left\{ |\Delta, s\rangle, |\Delta + \frac{1}{2}, s + \frac{1}{2}\rangle, |\Delta + \frac{1}{2}, s - \frac{1}{2}\rangle, |\Delta + 1, s\rangle \right\},$$

where we use $|\Delta, s\rangle$ to denote a CFT operator with conformal dimension Δ and spin s. Note that the long multiplets are constrained by the unitarity bound $\Delta > s + 1$. All 3d SCFTs contain a single short multiplet consisting of the energy-momentum tensor and the

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[8]For the 6 other supersymmetric critical points in table 2 the SCFT operator spectra and their organization into superconformal multiplets is presented in appendix B.

[9]These multiplets are denoted as A_1, L', and L in [51], respectively. The multiplets A_2' and B_1 in [51] correspond to a free $\mathcal{N} = 1$ chiral field and the identity operator, respectively, and will not play a role here.

supercurrent

$$\text{Short}\left[\frac{3}{2}\right] . \tag{4.3}$$

The remaining superconformal multiplets can be determined algorithmically by organizing the operator dimensions according to (4.2). Carrying out this procedure, we arrive at the following list

$$
\begin{aligned}
&\text{Long}\left[3.24233, 1\right], &&\text{Long}\left[3.21305, 1\right], &&\text{Long}\left[2.80439, 1\right], \\
&\text{Long}\left[2.77464, 1\right], &&\text{Long}\left[2.65832, 1\right], &&\text{Long}\left[2.60357, 1\right], \\
&\text{Long}\left[2.55537, 1\right], &&\text{Long}\left[3.72930, \frac{1}{2}\right], &&\text{Long}\left[3.68441, \frac{1}{2}\right], \\
&\text{Long}\left[3.57038, \frac{1}{2}\right], &&\text{Long}\left[3.49514, \frac{1}{2}\right], &&\text{Long}\left[3.45733, \frac{1}{2}\right], \\
&\text{Long}\left[3.43474, \frac{1}{2}\right], &&\text{Long}\left[3.33810, \frac{1}{2}\right], &&\text{Long}\left[3.23351, \frac{1}{2}\right], \\
&\text{Long}\left[3.12611, \frac{1}{2}\right], &&\text{Long}\left[1.96022, \frac{1}{2}\right], &&\text{Long}\left[1.95854, \frac{1}{2}\right], \\
&\text{Long}\left[1.80272, \frac{1}{2}\right], &&\text{Long}\left[1.78583, \frac{1}{2}\right], &&\text{Long}\left[1.50324, \frac{1}{2}\right], \\
&\text{Long}\left[4.14242, 0\right], &&\text{Long}\left[4.07003, 0\right], &&\text{Long}\left[3.95670, 0\right], \\
&\text{Long}\left[3.76103, 0\right], &&\text{Long}\left[3.71325, 0\right], &&\text{Long}\left[3.64839, 0\right], \\
&\text{Long}\left[3.06051, 0\right], &&\text{Long}\left[3.05548, 0\right], &&\text{Long}\left[3.00108, 0\right], \\
&\text{Long}\left[1.93113, 0\right], &&\text{Long}\left[1.53289, 0\right], &&\text{Long}\left[1.52514, 0\right], \\
&\text{Long}\left[1.52394, 0\right], &&\text{Long}\left[1.37406, 0\right].
\end{aligned}
\tag{4.4}
$$

Notice that all of these multiplets are long, and therefore unprotected, which is compatible with the expected behavior of a minimally supersymmetric SCFT with no continuous global symmetry.

Acknowledgments

A   Root generators of $E_{7(7)}$

$\alpha \in \Delta_+$	$\mathfrak{e}_\alpha$	$\mathfrak{f}_\alpha$	S_1	$S_1 S_2$	$S_1 S_2 S_3$
[1000000]	$t_1{}^2$	$t_2{}^1$	$*$		
[0100000]	$t_2{}^3$	$t_3{}^2$	$*$	$*$	
[0010000]	$t_3{}^4$	$t_4{}^3$			
[0001000]	$t_4{}^5$	$t_5{}^4$	$*$	$*$	
[0000100]	$t_5{}^6$	$t_6{}^5$	$*$		
[0000010]	$t_6{}^7$	$t_7{}^6$	$*$	$*$	
[0000001]	t_{5678}	t_{1234}			
[1100000]	$t_1{}^3$	$t_3{}^1$	$*$		
[0110000]	$t_2{}^4$	$t_4{}^2$			
[0011000]	$t_3{}^5$	$t_5{}^3$			
[0001100]	$t_4{}^6$	$t_6{}^4$	$*$		
[0000110]	$t_5{}^7$	$t_7{}^5$	$*$		
[0001001]	t_{4678}	t_{1235}			
[1110000]	$t_1{}^4$	$t_4{}^1$			
[0111000]	$t_2{}^5$	$t_5{}^2$			
[0011100]	$t_3{}^6$	$t_6{}^3$			
[0001110]	$t_4{}^7$	$t_7{}^4$	$*$		
[0001101]	t_{4578}	t_{1236}			
[0011001]	t_{3678}	t_{1245}	$*$		
[1111000]	$t_1{}^5$	$t_5{}^1$			
[0111100]	$t_2{}^6$	$t_6{}^2$			
[0011110]	$t_3{}^7$	$t_7{}^3$			
[0001111]	t_{4568}	t_{1237}			
[0011101]	t_{3578}	t_{1246}	$*$	$*$	
[0111001]	t_{2678}	t_{1345}	$*$		
[1111100]	$t_1{}^6$	$t_6{}^1$			
[0111110]	$t_2{}^7$	$t_7{}^2$			
[0011111]	t_{3568}	t_{1247}	$*$	$*$	$*$
[0012101]	t_{3478}	t_{1256}	$*$	$*$	$*$
[0111101]	t_{2578}	t_{1346}	$*$	$*$	$*$
[1111001]	t_{1678}	t_{2345}	$*$	$*$	$*$
[1111110]	$t_1{}^7$	$t_7{}^1$			
[0012111]	t_{3468}	t_{1257}	$*$	$*$	

$\alpha \in \Delta_+$	$\mathfrak{e}_\alpha$	$\mathfrak{f}_\alpha$	S_1	$S_1 S_2$	$S_1 S_2 S_3$
[0111111]	t_{2568}	t_{1347}	$*$	$*$	
[0112101]	t_{2478}	t_{1356}	$*$	$*$	
[1111101]	t_{1578}	t_{2346}	$*$		
[0012211]	t_{3458}	t_{1267}	$*$		
[0112111]	t_{2468}	t_{1357}	$*$	$*$	$*$
[0122101]	t_{2378}	t_{1456}			
[1112101]	t_{1478}	t_{2356}	$*$		
[1111111]	t_{1568}	t_{2347}	$*$		
[0112211]	t_{2458}	t_{1367}	$*$		
[1122101]	t_{1378}	t_{2456}			
[0122111]	t_{2368}	t_{1457}			
[1112111]	t_{1468}	t_{2357}	$*$		
[1222101]	t_{1278}	t_{3456}			
[1122111]	t_{1368}	t_{2457}			
[1112211]	t_{1458}	t_{2367}	$*$	$*$	$*$
[0122211]	t_{2358}	t_{1467}			
[1222111]	t_{1268}	t_{3457}			
[1122211]	t_{1358}	t_{2467}			
[0123211]	t_{2348}	t_{1567}			
[0123212]	$t_8{}^1$	$t_1{}^8$	$*$	$*$	
[1222211]	t_{1258}	t_{3467}			
[1123211]	t_{1348}	t_{2567}			
[1123212]	$t_8{}^2$	$t_2{}^8$	$*$		
[1223211]	t_{1248}	t_{3567}			
[1223212]	$t_8{}^3$	$t_3{}^8$	$*$		
[1233211]	t_{1238}	t_{4567}	$*$	$*$	$*$
[1233212]	$t_8{}^4$	$t_4{}^8$			
[1234212]	$t_8{}^5$	$t_5{}^8$			
[1234312]	$t_8{}^6$	$t_6{}^8$			
[1234322]	$t_8{}^7$	$t_7{}^8$			

Table 4. Positive and negative root generators of $E_{7(7)}$ with respect to the Cartan subalgebra (2.7). In the last three columns we indicate with a $*$ which root generators are invariant under the discrete symmetry actions S_1, $S_1 S_2$, and $S_1 S_2 S_3$.

B The spectra of supersymmetric AdS$_4$ vacua

Here we present the spectra of masses around the 6 supersymmetric AdS$_4$ vacua in table 2 and arrange them in superconformal multiplets. The spectrum of the new $\mathcal{N} = 1$ vacuum P355983405 is given in section 4.

P19987059.   This is an $\mathcal{N} = 1$ vacuum with

$$V = -\frac{2^{28/3} \times 3^{1/2}}{5^{5/2}}, \tag{B.1}$$

and G$_2$ continuous symmetry first discovered in [45] in massive type IIA supergravity. It was later rediscovered in four-dimensional supergravity in [46, 47] where the bosonic spectrum in four dimensions was determined. The complete four-dimensional mass spectrum is

$$m_\psi^2 L^2 : \left(\frac{3}{2}\right)_{\times 7}, \ 1_{\times 1}$$

$$m_A^2 L^2 : \left(\frac{3}{2} + \sqrt{\frac{3}{2}}\right)_{\times 7}, \ \left(\frac{3}{2} - \sqrt{\frac{3}{2}}\right)_{\times 7}, \ 0_{\times 14},$$

$$m_\chi^2 L^2 : 6_{\times 8}, \ \left(\frac{3}{2}\right)_{\times 7}, \ \left(\frac{1}{6}\right)_{\times 27}, \ 0_{\times 14},$$

$$m_\phi^2 L^2 : (4 + \sqrt{6})_{\times 1}, \ (4 - \sqrt{6})_{\times 1}, \ 0_{\times 14}, \ \left(-\frac{11}{6} + \sqrt{\frac{1}{6}}\right)_{\times 27}, \ \left(-\frac{11}{6} - \sqrt{\frac{1}{6}}\right)_{\times 27}.$$

We can translate this into conformal dimensions for the dual 3d CFT operators and organize them in superconformal multiplets as described in section 4. This results in 2 short

$$\mathrm{Short}\left[\frac{3}{2}\right]_{\times 1}, \quad \mathrm{Short}\left[\frac{1}{2}\right]_{\times 14}, \tag{B.2}$$

and 3 long multiplets

$$\mathrm{Long}\left[1 + \sqrt{\frac{3}{2}}, 1\right]_{\times 7}, \quad \mathrm{Long}\left[1 + \sqrt{6}, 0\right]_{\times 1}, \quad \mathrm{Long}\left[1 + \sqrt{\frac{1}{6}}, 0\right]_{\times 27}. \tag{B.3}$$

P20784609.   This is an $\mathcal{N} = 2$ vacuum with

$$V = -2^2 \times 3^{3/2}, \tag{B.4}$$

and SU(3) × U(1) continuous symmetry. The solution was first studied in [21] and the four-dimensional bosonic spectrum was computed in [3]. The complete four-dimensional mass spectrum including also fermionic fluctuations is

$$m_\psi^2 L^2 : \left(\frac{16}{9}\right)_{\times 6}, \ 1_{\times 2}$$

$$m_A^2 L^2 : 4_{\times 1}, \ \left(\frac{28}{9}\right)_{\times 6}, \ \left(\frac{4}{9}\right)_{\times 12}, \ 0_{\times 9},$$

$$m_\chi^2 L^2 : \left(\frac{64}{9}\right)_{\times 6}, \ \left(\frac{9}{2} + \sqrt{\frac{17}{4}}\right)_{\times 2}, \ \left(\frac{9}{2} - \sqrt{\frac{17}{4}}\right)_{\times 2}, \ \left(\frac{16}{9}\right)_{\times 12}, \ \left(\frac{1}{9}\right)_{\times 18}, \ 0_{\times 16},$$

$$m_\phi^2 L^2 : (3 + \sqrt{17})_{\times 1}, \ 2_{\times 3}, \ 0_{\times 19}, \ (3 - \sqrt{17})_{\times 1}, \ \left(-\frac{14}{9}\right)_{\times 18}, \ (-2)_{\times 16}, \ \left(-\frac{20}{9}\right)_{\times 12}.$$

To map this supergravity mass spectrum to 3d $\mathcal{N} = 2$ superconformal multiplets we use the results and notation in [51]. The SCFT at hand has the following spectrum of low lying operators[10]

- The $\mathcal{N} = 2$ energy-momentum tensor multiplet $A_1\bar{A}_1[2]_2^{(0)}$

$$|2, 1\rangle\,, \qquad |\frac{5}{2}, \frac{3}{2}\rangle \times 2\,, \qquad |3, 2\rangle\,. \tag{B.5}$$

- 8 $A_2\bar{A}_2[0]_1^{(0)}$ conserved current multiplets corresponding to the SU(3) flavor symmetry

$$|1, 0\rangle\,, \qquad |\frac{3}{2}, \frac{1}{2}\rangle \times 2\,, \qquad |2, 1\rangle\,, \qquad |2, 0\rangle\,. \tag{B.6}$$

- 6 $L\bar{A}[1]_{\frac{11}{6}}$ semi-short multiplets

$$|\frac{11}{6}, \frac{1}{2}\rangle\,, \qquad |\frac{7}{3}, 1\rangle \times 2\,, \qquad |\frac{7}{3}, 0\rangle\,, \qquad |\frac{17}{6}, \frac{1}{2}\rangle \times 2\,, \qquad |\frac{17}{6}, \frac{3}{2}\rangle\,, \qquad |\frac{10}{3}, 1\rangle\,. \tag{B.7}$$

- 12 $L\bar{B}[0]_{\frac{4}{3}}$ semi-short multiplets

$$|\frac{4}{3}, 0\rangle\,, \qquad |\frac{11}{6}, \frac{1}{2}\rangle\,, \qquad |\frac{7}{3}, 0\rangle\,. \tag{B.8}$$

- 1 long $L\bar{L}[0]_{\frac{1}{2}+\frac{\sqrt{17}}{2}}$ multiplet

$$\begin{aligned} &|\frac{1}{2} + \frac{\sqrt{17}}{2}, 0\rangle\,, \qquad |1 + \frac{\sqrt{17}}{2}, \frac{1}{2}\rangle \times 2\,, \qquad |\frac{3}{2} + \frac{\sqrt{17}}{2}, 0\rangle \times 3\,, \\ &|\frac{3}{2} + \frac{\sqrt{17}}{2}, 1\rangle\,, \qquad |2 + \frac{\sqrt{17}}{2}, \frac{1}{2}\rangle \times 2\,, \qquad |\frac{5}{2} + \frac{\sqrt{17}}{2}, 0\rangle\,. \end{aligned} \tag{B.9}$$

The full KK spectrum of massive IIA supergravity for this AdS$_4$ vacuum was recently computed in [52] using the techniques developed in [29, 30].

P23277304$_1$. This is an $\mathcal{N} = 3$ vacuum with

$$V = -\frac{2^{16/3}}{3^{1/2}}\,, \tag{B.10}$$

and SU(2) $\times$ SU(2) continuous symmetry. The solution was first studied in [48] where the four-dimensional spectrum was computed. We repeat it here

$$m_\psi^2 L^2 : 3_{\times 1}\,, \ \left(\frac{9}{4}\right)_{\times 4}\,, \ 1_{\times 3}$$

$$m_A^2 L^2 : (3 + \sqrt{3})_{\times 3}\,, \ \left(\frac{15}{4}\right)_{\times 4}\,, \ (3 - \sqrt{3})_{\times 3}\,, \ \left(\frac{3}{4}\right)_{\times 12}\,, \ 0_{\times 6}\,,$$

$$m_\chi^2 L^2 : 12_{\times 1}\,, \ 9_{\times 4}\,, \ (4 + 2\sqrt{3})_{\times 3}\,, \ 3_{\times 8}\,, \ \left(\frac{9}{4}\right)_{\times 12}\,, \ (4 - 2\sqrt{3})_{\times 3}\,, \ \left(\frac{1}{4}\right)_{\times 12}\,, \ 0_{\times 13}\,,$$

$$m_\phi^2 L^2 : (3 + 3\sqrt{3})_{\times 1}\,, \ (1 + \sqrt{3})_{\times 6}\,, \ 0_{\times 22}\,, \ (1 - \sqrt{3})_{\times 6}\,,$$

$$\left(-\frac{5}{4}\right)_{\times 12}\,, \ (-2)_{\times 18}\,, \ (3 - 3\sqrt{3})_{\times 1}\,, \ \left(-\frac{9}{4}\right)_{\times 4}\,.$$

---

[10]We use the notation $|\Delta, s\rangle$ to denote individual operators in a given multiplet.

To map the supergravity mass spectrum to 3d $\mathcal{N} = 3$ superconformal multiplets we use the results and notation in [51]. The SCFT at hand has the following low-lying spectrum

- The $\mathcal{N} = 3$ EM tensor multiplet $A_1[1]_{\frac{3}{2}}^{(0)}$

$$|\frac{3}{2}, \frac{1}{2}\rangle, \qquad |2,1\rangle \times 3, \qquad |\frac{5}{2}, \frac{3}{2}\rangle \times 3, \qquad |3,2\rangle. \tag{B.11}$$

- 3 $B_1[0]_1^{(2)}$ current multiplets corresponding to the SO(3) flavor symmetry

$$|1,0\rangle \times 3, \qquad |\frac{3}{2}, \frac{1}{2}\rangle \times 4, \qquad |2,1\rangle, \qquad |2,0\rangle \times 3. \tag{B.12}$$

- 2 $A_2[0]_{\frac{3}{2}}^{(1)}$ semi-short multiplets

$$
\begin{aligned}
&|\frac{3}{2},0\rangle \times 2, &\qquad &|2,\frac{1}{2}\rangle \times 6, &\qquad &|\frac{5}{2},1\rangle \times 6, &\qquad &|\frac{5}{2},0\rangle \times 6, \\
&|3,\frac{3}{2}\rangle \times 2, &\qquad &|3,\frac{1}{2}\rangle \times 6, &\qquad &|\frac{7}{2},1\rangle \times 2.
\end{aligned}
\tag{B.13}
$$

- 1 long $L[0]_{\sqrt{3}}^{(0)}$ multiplet with the following content

$$
\begin{aligned}
&|\sqrt{3},0\rangle, &\quad &|\frac{1}{2}+\sqrt{3},\frac{1}{2}\rangle \times 3, &\quad &|1+\sqrt{3},0\rangle \times 6 &\quad &|1+\sqrt{3},1\rangle \times 3, &\quad &|\frac{3}{2}+\sqrt{3},\frac{1}{2}\rangle \times 8, \\
&|\frac{3}{2}+\sqrt{3},\frac{3}{2}\rangle, &\quad &|2+\sqrt{3},0\rangle \times 6, &\quad &|2+\sqrt{3},1\rangle \times 3, &\quad &|\frac{5}{2}+\sqrt{3},\frac{1}{2}\rangle \times 3, &\quad &|3+\sqrt{3},0\rangle \times 1.
\end{aligned}
\tag{B.14}
$$

The full KK spectrum of massive IIA supergravity for this AdS$_4$ vacuum was recently computed in [52] using the techniques developed in [29, 30].

P23795609. This is an $\mathcal{N} = 1$ vacuum with

$$V = -\frac{2^8 \times 3^{3/2}}{5^{5/2}}, \tag{B.15}$$

and SU(3) continuous symmetry. The solution was first studied in [3] where the four-dimensional bosonic spectrum was computed. The complete four-dimensional mass spectrum including also fermionic fluctuations is

$$m_\psi^2 L^2 : 4_{\times 1}, \; \left(\frac{16}{9}\right)_{\times 6}, \; 1_{\times 1}$$

$$m_A^2 L^2 : 6_{\times 1}, \; \left(\frac{28}{9}\right)_{\times 6}, \; \left(\frac{25}{9}\right)_{\times 6}, \; 2_{\times 1}, \; \left(\frac{4}{9}\right)_{\times 6}, \; 0_{\times 8},$$

$$m_\chi^2 L^2 : 16_{\times 1}, \; \left(\frac{64}{9}\right)_{\times 6}, \; 6_{\times 2}, \; \left(\frac{59}{18}+\frac{\sqrt{109}}{6}\right)_{\times 6}, \; 4_{\times 1}, \; \left(\frac{16}{9}\right)_{\times 6},$$

$$\left(\frac{59}{18}-\frac{\sqrt{109}}{6}\right)_{\times 6}, \; 1_{\times 8}, \; \left(\frac{4}{9}\right)_{\times 12}, \; 0_{\times 8},$$

$$m_\phi^2 L^2 : (4+\sqrt{6})_{\times 2}, \; (4-\sqrt{6})_{\times 2}, \; \left(\frac{7}{9}\right)_{\times 6}, \; 0_{\times 28}, \; \left(-\frac{8}{9}\right)_{\times 12}, \; (-2)_{\times 8}, \; \left(-\frac{20}{9}\right)_{\times 12}.$$

The spectrum of low-dimension operators in the dual 3d $\mathcal{N} = 1$ CFT can be organized into the following short

$$\text{Short}\left[\frac{3}{2}\right]_{\times 1}, \quad \text{Short}\left[\frac{1}{2}\right]_{\times 8}, \tag{B.16}$$

and long multiplets

$$\text{Long}[3,1]_{\times 1}, \qquad \text{Long}\left[\frac{7}{3},1\right]_{\times 6}, \qquad \text{Long}\left[1+\sqrt{\frac{109}{36}},\frac{1}{2}\right]_{\times 6},$$
$$\text{Long}\left[1+\sqrt{6},0\right]_{\times 2}, \qquad \text{Long}[2,0]_{\times 8}, \qquad \text{Long}\left[\frac{5}{3},0\right]_{\times 12}. \tag{B.17}$$

P25697101. This is an $\mathcal{N} = 1$ vacuum with

$$V \approx -25.697101, \tag{B.18}$$

and U(1) continuous symmetry. The solution was first studied in [24] and the four-dimensional bosonic spectrum was computed in [20]. The complete four-dimensional mass spectrum including also fermionic fluctuations is

$m_\psi^2 L^2 : 4.02416_{\times 1}, \ 2.94452_{\times 1}, \ 2.78901_{\times 1}, \ 2.16471_{\times 2}, \ 1.61937_{\times 2}, \ 1_{\times 1},$

$m_A^2 L^2 : 6.03020_{\times 1}, \ 5.71869_{\times 2}, \ 4.74884_{\times 2}, \ 4.66048_{\times 1}, \ 4.45905_{\times 1},$
$\qquad 3.63601_{\times 2}, \ 2.89191_{\times 2}, \ 2.01813_{\times 1}, \ 1.91361_{\times 2}, \ 1.22856_{\times 1},$
$\qquad 1.11898_{\times 1}, \ 0.710738_{\times 1}, \ 0.693418_{\times 2}, \ 0.615608_{\times 1}, \ 0.359215_{\times 1},$
$\qquad 0.346824_{\times 2}, \ 0.250555_{\times 2}, \ 0.177244_{\times 2}, \ 0_{\times 1},$

$m_\chi^2 L^2 : 16.0967_{\times 1}, \ 11.7781_{\times 1}, \ 11.1561_{\times 1}, \ 8.66178_{\times 2}, \ 8.65886_{\times 2},$
$\qquad 7.48465_{\times 2}, \ 7.43727_{\times 1}, \ 7.38170_{\times 2}, \ 6.47747_{\times 2}, \ 4.17826_{\times 1},$
$\qquad 4.02416_{\times 1}, \ 3.88453_{\times 2}, \ 3.77560_{\times 2}, \ 3.22624_{\times 1}, \ 3.01303_{\times 2},$
$\qquad 2.94452_{\times 1}, \ 2.78901_{\times 1}, \ 2.19091_{\times 1}, \ 2.16471_{\times 2}, \ 2.04599_{\times 1},$
$\qquad 1.63974_{\times 1}, \ 1.61937_{\times 2}, \ 1.54207_{\times 1}, \ 1.45805_{\times 2}, \ 1.33088_{\times 2},$
$\qquad 0.942689_{\times 2}, \ 0.230565_{\times 1}, \ 0.185227_{\times 1}, \ 0.158783_{\times 2}, \ 0.0850812_{\times 1},$
$\qquad 0.0786929_{\times 1}, \ 0.0430559_{\times 2}, \ 0.0335791_{\times 1}, \ 0.0236049_{\times 2}, \ 0.0149976_{\times 2},$
$\qquad 0.0123450_{\times 1}, \ 0.00175250_{\times 2}, \ 0_{\times 1},$

$m_\phi^2 L^2 : 8.16441_{\times 1}, \ 8.09862_{\times 2}, \ 4.22234_{\times 1}, \ 3.71869_{\times 2}, \ 3.02242_{\times 1},$
$\qquad 2.74884_{\times 2}, \ 2.71014_{\times 1}, \ 2.66477_{\times 2}, \ 0.783875_{\times 1}, \ 0.134180_{\times 1},$
$\qquad 0_{\times 27}, \ -0.0863888_{\times 2}, \ -0.569930_{\times 1}, \ -1.28926_{\times 1}, \ -1.38439_{\times 1},$
$\qquad -1.44274_{\times 2}, \ -1.62323_{\times 1}, \ -1.64078_{\times 1}, \ -1.69973_{\times 1}, \ -1.74944_{\times 2},$
$\qquad -1.78317_{\times 1}, \ -1.82276_{\times 2}, \ -1.86254_{\times 2}, \ -1.87655_{\times 1}, \ -1.95638_{\times 2},$
$\qquad -2.04011_{\times 2}, \ -2.09876_{\times 1}, \ -2.10747_{\times 2}, \ -2.14967_{\times 1}, \ -2.20661_{\times 1},$
$\qquad -2.23969_{\times 2},$

The spectrum of low-dimension operators in the dual 3d $\mathcal{N} = 1$ CFT can be organized into the following short

$$\text{Short}\left[\frac{3}{2}\right]_{\times 1}, \quad \text{Short}\left[\frac{1}{2}\right]_{\times 1}, \tag{B.19}$$

and long multiplets

$$
\begin{aligned}
&\text{Long}[3.00603, 1]_{\times 1}\,, \quad \text{Long}[2.71596, 1]_{\times 1}\,, \quad \text{Long}[2.67003, 1]_{\times 1}\,, \\
&\text{Long}[2.47130, 1]_{\times 2}\,, \quad \text{Long}[2.27254, 1]_{\times 2}\,, \quad \text{Long}\left[3.44309, \frac{1}{2}\right]_{\times 2}\,, \\
&\text{Long}\left[3.23581, \frac{1}{2}\right]_{\times 2}\,, \quad \text{Long}\left[2.47092, \frac{1}{2}\right]_{\times 2}\,, \quad \text{Long}\left[1.98017, \frac{1}{2}\right]_{\times 1}\,, \\
&\text{Long}\left[1.93038, \frac{1}{2}\right]_{\times 1}\,, \quad \text{Long}\left[1.78052, \frac{1}{2}\right]_{\times 1}\,, \quad \text{Long}\left[1.70750, \frac{1}{2}\right]_{\times 2}\,, \\
&\text{Long}\left[1.65364, \frac{1}{2}\right]_{\times 2}\,, \quad \text{Long}[3.72714, 0]_{\times 1}\,, \quad \text{Long}[3.71693, 0]_{\times 2}\,, \\
&\text{Long}[3.04408, 0]_{\times 1}\,, \quad \text{Long}[2.79617, 0]_{\times 1}\,, \quad \text{Long}[2.24180, 0]_{\times 1}\,, \\
&\text{Long}[1.39848, 0]_{\times 2}\,, \quad \text{Long}[1.29169, 0]_{\times 1}\,, \quad \text{Long}[1.18325, 0]_{\times 1}\,, \\
&\text{Long}[1.12246, 0]_{\times 2}\,, \quad \text{Long}[1.11111, 0]_{\times 1}\,, \quad \text{Long}[1.04186, 0]_{\times 2}\,.
\end{aligned}
\tag{B.20}
$$

P35610235. This is an $\mathcal{N} = 1$ vacuum with

$$
V \approx -35.610235\,,
\tag{B.21}
$$

and U(1) continuous symmetry. The solution was first studied in [24] and the four-dimensional bosonic spectrum was computed in [20]. The complete four-dimensional mass spectrum including also fermionic fluctuations is

$$
\begin{aligned}
m_\psi^2 L^2 : \ & 4.96968_{\times 1}\,, \ 4.73233_{\times 1}\,, \ 3.20491_{\times 2}\,, \ 2.80058_{\times 1}\,, \ 2.55832_{\times 2}\,, \ 1_{\times 1}\,, \\
m_A^2 L^2 : \ & 7.19896_{\times 1}\,, \ 6.90772_{\times 1}\,, \ 6.76499_{\times 1}\,, \ 6.24465_{\times 1}\,, \ 6.05457_{\times 2}\,, \\
& 5.93897_{\times 2}\,, \ 5.61325_{\times 1}\,, \ 4.99513_{\times 2}\,, \ 4.71417_{\times 2}\,, \ 4.47408_{\times 1}\,, \\
& 4.15780_{\times 2}\,, \ 2.74040_{\times 1}\,, \ 2.55694_{\times 1}\,, \ 1.41468_{\times 2}\,, \ 1.12709_{\times 1}\,, \\
& 0.958848_{\times 2}\,, \ 0.654210_{\times 2}\,, \ 0.384736_{\times 2}\,, \ 0_{\times 1}\,, \\
m_\chi^2 L^2 : \ & 19.8787_{\times 1}\,, \ 18.9293_{\times 1}\,, \ 12.8196_{\times 2}\,, \ 11.2023_{\times 1}\,, \ 10.2333_{\times 2}\,, \\
& 9.91358_{\times 1}\,, \ 9.73539_{\times 1}\,, \ 9.29311_{\times 1}\,, \ 9.12144_{\times 1}\,, \ 9.06547_{\times 2}\,, \\
& 8.92674_{\times 2}\,, \ 8.83658_{\times 1}\,, \ 8.53466_{\times 1}\,, \ 7.56477_{\times 2}\,, \ 7.44222_{\times 2}\,, \\
& 6.93688_{\times 1}\,, \ 4.96968_{\times 1}\,, \ 4.73233_{\times 1}\,, \ 4.61641_{\times 1}\,, \ 4.19619_{\times 1}\,, \\
& 4.09060_{\times 2}\,, \ 4.04368_{\times 2}\,, \ 4.02032_{\times 1}\,, \ 3.95121_{\times 2}\,, \ 3.69183_{\times 1}\,, \\
& 3.20491_{\times 2}\,, \ 2.98613_{\times 2}\,, \ 2.80058_{\times 1}\,, \ 2.55832_{\times 2}\,, \ 2.10511_{\times 2}\,, \\
& 1.68144_{\times 2}\,, \ 1.07685_{\times 2}\,, \ 0.310663_{\times 1}\,, \ 0.281223_{\times 2}\,, \ 0.203311_{\times 2}\,, \\
& 0.157113_{\times 1}\,, \ 0.0880327_{\times 2}\,, \ 0_{\times 1}\,, \\
m_\phi^2 L^2 : \ & 10.8555_{\times 1}\,, \ 10.1416_{\times 1}\,, \ 9.80922_{\times 1}\,, \ 8.31518_{\times 2}\,, \ 7.57067_{\times 1}\,, \\
& 4.76499_{\times 1}\,, \ 4.61523_{\times 1}\,, \ 4.24465_{\times 1}\,, \ 4.11312_{\times 2}\,, \ 4.10127_{\times 1}\,, \\
& 4.05457_{\times 2}\,, \ 4.02540_{\times 1}\,, \ 3.93897_{\times 2}\,, \ 3.86395_{\times 1}\,, \ 3.61325_{\times 1}\,, \\
& 2.81436_{\times 2}\,, \ 2.71417_{\times 2}\,, \ 2.30308_{\times 1}\,, \ 0.114560_{\times 2}\,, \ 0.0680744_{\times 2}\,,
\end{aligned}
$$

$$0.0152488_{\times 1}, \ 0_{\times 27}, \ -1.13197_{\times 1}, \ -1.18847_{\times 2}, \ -1.34579_{\times 2},$$
$$-1.44651_{\times 1}, \ -1.61526_{\times 2}, \ -1.96087_{\times 2}, \ -2.23926_{\times 1}, \ -2.24671_{\times 1},$$
$$-2.24908_{\times 2},$$

The spectrum of low-dimension operators in the dual 3d $\mathcal{N}=1$ CFT can be organized into the following short

$$\text{Short}\left[\frac{3}{2}\right]_{\times 1}, \quad \text{Short}\left[\frac{1}{2}\right]_{\times 1}, \tag{B.22}$$

and long multiplets

$$
\begin{array}{lll}
\text{Long}[3.22928,1]_{\times 1}, & \text{Long}[3.17539,1]_{\times 1}, & \text{Long}[2.79023,1]_{\times 2}, \\[2mm]
\text{Long}[2.67349,1]_{\times 1}, & \text{Long}[2.59948,1]_{\times 2}, & \text{Long}\left[3.64858,\frac{1}{2}\right]_{\times 1}, \\[2mm]
\text{Long}\left[3.54846,\frac{1}{2}\right]_{\times 1}, & \text{Long}\left[3.51089,\frac{1}{2}\right]_{\times 2}, & \text{Long}\left[3.48776,\frac{1}{2}\right]_{\times 2}, \\[2mm]
\text{Long}\left[3.42141,\frac{1}{2}\right]_{\times 1}, & \text{Long}\left[3.22804,\frac{1}{2}\right]_{\times 2}, & \text{Long}\left[1.95090,\frac{1}{2}\right]_{\times 2}, \\[2mm]
\text{Long}\left[1.79670,\frac{1}{2}\right]_{\times 2}, & \text{Long}[4.12016,0]_{\times 1}, & \text{Long}[4.02017,0]_{\times 1}, \\[2mm]
\text{Long}[3.97264,0]_{\times 1}, & \text{Long}[3.75041,0]_{\times 2}, & \text{Long}[3.63380,0]_{\times 1}, \\[2mm]
\text{Long}[3.02252,0]_{\times 2}, & \text{Long}[3.00507,0]_{\times 1}, & \text{Long}[2.03771,0]_{\times 2}, \\[2mm]
\text{Long}[1.55737,0]_{\times 1}, & \text{Long}[1.53030,0]_{\times 2}, & \text{Long}[1.39637,0]_{\times 1}.
\end{array}
\tag{B.23}
$$

C   The spectra of BF stable non-supersymmetric AdS$_4$ vacua

Here we present the spectra of masses for all fields in the 4d gauged supergravity theory around each of the 9 non-supersymmetric but BF stable AdS$_4$ solutions listed in table 2. We do not explicitly list the massless spin-2 mode present in each one of these vacua. We remind the reader that the BF bound for scalars fields in AdS$_4$ is $m^2 L^2 \geq -\frac{9}{4}$.

P23277304$_2$.

$$m_\psi^2 L^2 : \frac{9}{2}_{\times 1}, \ \frac{3}{2}_{\times 7},$$
$$m_A^2 L^2 : 3_{\times 14}, \ 0_{\times 14},$$
$$m_\chi^2 L^2 : 18_{\times 1}, \ 6_{\times 7}, \ \frac{9}{2}_{\times 7}, \ \frac{3}{2}_{\times 14}, \ \frac{1}{2}_{\times 27},$$
$$m_\phi^2 L^2 : 6_{\times 2}, \ 0_{\times 14}, \ -1_{\times 54},$$

P23413628.

$m_\psi^2 L^2 : 4.47622_{\times 1}, 1.58653_{\times 6}, 1.25039_{\times 1},$

$m_A^2 L^2 : 4.37314_{\times 1}, 3.19992_{\times 6}, 2.79117_{\times 6}, 2.49049_{\times 1}, 0.110741_{\times 6}, 0_{\times 8},$

$m_\chi^2 L^2 : 17.9049_{\times 1}, 6.34611_{\times 6}, 5.71339_{\times 1}, 5.00155_{\times 1}, 4.54552_{\times 6},$
$\qquad 2.18869_{\times 6}, 1.41227_{\times 1}, 1.25322_{\times 8}, 0.590312_{\times 12}, 0.562809_{\times 6},$
$\qquad 0.177942_{\times 8},$

$m_\phi^2 L^2 : 6.22958_{\times 1}, 5.90489_{\times 1}, 1.12990_{\times 1}, 0_{\times 20}, -0.308840_{\times 8},$
$\qquad -0.954193_{\times 12}, -1.08192_{\times 6}, -1.26438_{\times 1}, -1.39571_{\times 8}, -1.58174_{\times 12},$

P23456052.

$m_\psi^2 L^2 : 4.34233_{\times 1}, 1.71978_{\times 4}, 1.32170_{\times 2}, 1.28551_{\times 1},$

$m_A^2 L^2 : 4.29451_{\times 1}, 3.62600_{\times 2}, 3.31200_{\times 4}, 2.66757_{\times 2}, 2.39744_{\times 4},$
$\qquad 2.29373_{\times 1}, 0.125393_{\times 4}, 0.0883439_{\times 2}, 0.0526758_{\times 4}, 0_{\times 4},$

$m_\chi^2 L^2 : 17.3693_{\times 1}, 6.87911_{\times 4}, 5.57377_{\times 1}, 5.42827_{\times 2}, 5.28681_{\times 2},$
$\qquad 5.14204_{\times 1}, 4.10476_{\times 4}, 2.05956_{\times 2}, 1.93584_{\times 4}, 1.58453_{\times 4},$
$\qquad 1.57432_{\times 1}, 1.42881_{\times 1}, 1.08509_{\times 2}, 0.817300_{\times 3}, 0.763508_{\times 2},$
$\qquad 0.636613_{\times 4}, 0.361814_{\times 4}, 0.339602_{\times 6}, 0.249058_{\times 3}, 0.237591_{\times 4},$
$\qquad 0.173874_{\times 1},$

$m_\phi^2 L^2 : 6.29251_{\times 1}, 5.78023_{\times 1}, 1.14647_{\times 1}, 0_{\times 24}, -0.0277198_{\times 2},$
$\qquad -0.145118_{\times 1}, -0.825771_{\times 4}, -0.920226_{\times 2}, -0.987543_{\times 1}, -1.13572_{\times 4},$
$\qquad -1.16949_{\times 3}, -1.26471_{\times 6}, -1.36606_{\times 2}, -1.38584_{\times 4}, -1.56985_{\times 3},$
$\qquad -1.58248_{\times 1}, -1.62006_{\times 6}, -1.71379_{\times 4},$

P23456098.

$m_\psi^2 L^2 : 4.34248_{\times 1}, 1.72262_{\times 4}, 1.32252_{\times 1}, 1.30762_{\times 1}, 1.28725_{\times 1},$

$m_A^2 L^2 : 4.26513_{\times 1}, 3.70813_{\times 1}, 3.59326_{\times 1}, 3.31546_{\times 4}, 2.67942_{\times 1},$
$\qquad 2.63558_{\times 1}, 2.39041_{\times 4}, 2.30724_{\times 1}, 0.123236_{\times 4}, 0.0948198_{\times 1},$
$\qquad 0.0753444_{\times 1}, 0.0562524_{\times 4}, 0.00171607_{\times 1}, 0_{\times 3},$

$m_\chi^2 L^2 : 17.3699_{\times 1}, 6.89048_{\times 4}, 5.56531_{\times 1}, 5.47446_{\times 1}, 5.41899_{\times 1},$
$\qquad 5.29008_{\times 1}, 5.23049_{\times 1}, 5.14900_{\times 1}, 4.09224_{\times 4}, 2.10385_{\times 1},$
$\qquad 1.99973_{\times 1}, 1.93008_{\times 4}, 1.59837_{\times 4}, 1.59825_{\times 1}, 1.41838_{\times 1},$
$\qquad 1.10589_{\times 1}, 1.08716_{\times 1}, 0.809770_{\times 3}, 0.798969_{\times 1}, 0.751003_{\times 1},$
$\qquad 0.638581_{\times 4}, 0.356887_{\times 4}, 0.348094_{\times 3}, 0.317619_{\times 3}, 0.254423_{\times 3},$
$\qquad 0.239296_{\times 4}, 0.171334_{\times 1},$

$m_\phi^2 L^2 : 6.29845_{\times 1}, 5.77263_{\times 1}, 1.14238_{\times 1}, 0.0395421_{\times 1}, 0_{\times 25},$
$\qquad -0.214610_{\times 1}, -0.834473_{\times 4}, -0.874352_{\times 1}, -0.960622_{\times 1}, -0.977451_{\times 1},$

$-1.13165_{\times 4}$, $-1.20232_{\times 3}$, $-1.27193_{\times 3}$, $-1.28289_{\times 3}$, $-1.34552_{\times 1}$,

$-1.35168_{\times 1}$, $-1.37196_{\times 4}$, $-1.56255_{\times 3}$, $-1.57899_{\times 3}$, $-1.58451_{\times 1}$,

$-1.64152_{\times 3}$, $-1.71663_{\times 4}$,

P23456778.

$m_\psi^2 L^2 : 4.35284_{\times 1}$, $1.59271_{\times 6}$, $1.27532_{\times 1}$,

$m_A^2 L^2 : 4.67676_{\times 1}$, $3.18378_{\times 6}$, $2.71517_{\times 6}$, $2.13568_{\times 1}$, $0.150049_{\times 6}$, $0_{\times 8}$,

$m_\chi^2 L^2 : 17.4114_{\times 1}$, $6.37083_{\times 6}$, $5.68294_{\times 1}$, $5.10127_{\times 1}$, $4.63416_{\times 6}$,

$\qquad 2.06315_{\times 6}$, $1.57957_{\times 1}$, $1.21768_{\times 8}$, $0.566626_{\times 12}$, $0.509940_{\times 6}$,

$\qquad 0.191836_{\times 8}$,

$m_\phi^2 L^2 : 6.21445_{\times 1}$, $5.92510_{\times 1}$, $1.14480_{\times 1}$, $0_{\times 20}$, $-0.158522_{\times 8}$,

$\qquad -0.859766_{\times 12}$, $-1.06147_{\times 6}$, $-1.28435_{\times 1}$, $-1.62283_{\times 8}$, $-1.70679_{\times 12}$,

P23458779.

$m_\psi^2 L^2 : 4.35028_{\times 1}$, $1.65919_{\times 4}$, $1.45670_{\times 2}$, $1.27671_{\times 1}$,

$m_A^2 L^2 : 4.59692_{\times 1}$, $3.26745_{\times 2}$, $3.24580_{\times 4}$, $2.82061_{\times 2}$, $2.55925_{\times 4}$,

$\qquad 2.16737_{\times 1}$, $0.147874_{\times 4}$, $0.132118_{\times 2}$, $0.0115978_{\times 4}$, $0_{\times 4}$,

$m_\chi^2 L^2 : 17.4011_{\times 1}$, $6.63676_{\times 4}$, $5.82678_{\times 2}$, $5.65794_{\times 1}$, $5.10682_{\times 1}$,

$\qquad 5.07034_{\times 2}$, $4.37936_{\times 4}$, $2.09910_{\times 2}$, $2.03236_{\times 4}$, $1.54604_{\times 1}$,

$\qquad 1.43198_{\times 1}$, $1.36513_{\times 4}$, $0.997243_{\times 3}$, $0.796384_{\times 2}$, $0.614906_{\times 2}$,

$\qquad 0.604950_{\times 4}$, $0.458648_{\times 6}$, $0.452034_{\times 4}$, $0.202040_{\times 4}$, $0.200635_{\times 3}$,

$\qquad 0.193346_{\times 1}$,

$m_\phi^2 L^2 : 6.22349_{\times 1}$, $5.89550_{\times 1}$, $1.16111_{\times 1}$, $0.0852111_{\times 1}$, $0_{\times 24}$,

$\qquad -0.480612_{\times 2}$, $-0.627003_{\times 3}$, $-0.804699_{\times 4}$, $-0.935656_{\times 2}$, $-1.04651_{\times 6}$,

$\qquad -1.12566_{\times 4}$, $-1.22285_{\times 1}$, $-1.55930_{\times 4}$, $-1.58649_{\times 1}$, $-1.59719_{\times 2}$,

$\qquad -1.63609_{\times 3}$, $-1.69541_{\times 4}$, $-1.70677_{\times 6}$,

P23512689.

$m_\psi^2 L^2 : 4.11184_{\times 1}$, $1.87329_{\times 4}$, $1.15576_{\times 3}$,

$m_A^2 L^2 : 4.15307_{\times 3}$, $3.45088_{\times 4}$, $2.28714_{\times 3}$, $1.94511_{\times 4}$, $0.191140_{\times 8}$, $0_{\times 6}$,

$m_\chi^2 L^2 : 16.4474_{\times 1}$, $7.49316_{\times 4}$, $5.99779_{\times 3}$, $4.62306_{\times 3}$, $3.65501_{\times 4}$,

$\qquad 1.76841_{\times 8}$, $1.67139_{\times 5}$, $1.35101_{\times 3}$, $0.736915_{\times 4}$, $0.456425_{\times 3}$,

$\qquad 0.234629_{\times 8}$, $0.178226_{\times 9}$, $0.0434607_{\times 1}$,

$m_\phi^2 L^2 : 6.72740_{\times 1}$, $5.28662_{\times 1}$, $0.629766_{\times 5}$, $0.584358_{\times 1}$, $0_{\times 22}$,

$\qquad -0.729624_{\times 4}$, $-0.982712_{\times 5}$, $-1.17591_{\times 8}$, $-1.58552_{\times 1}$, $-1.58816_{\times 9}$,

$\qquad -1.75110_{\times 9}$, $-1.96422_{\times 4}$,

P23715872.

$m_\psi^2 L^2 : 4.05937_{\times 1}$, $1.97687_{\times 2}$, $1.82407_{\times 1}$, $1.81894_{\times 1}$, $1.37617_{\times 2}$,
  $1.06398_{\times 1}$,

$m_A^2 L^2 : 5.48592_{\times 1}$, $3.72565_{\times 2}$, $3.37821_{\times 2}$, $3.31705_{\times 1}$, $3.21520_{\times 1}$,
  $2.87561_{\times 1}$, $2.71437_{\times 2}$, $2.33181_{\times 1}$, $1.91237_{\times 2}$, $1.70402_{\times 1}$,
  $0.473109_{\times 1}$, $0.451036_{\times 2}$, $0.417981_{\times 1}$, $0.159393_{\times 2}$, $0.0756985_{\times 2}$,
  $0.0671494_{\times 2}$, $0.0190147_{\times 1}$, $0.0135513_{\times 2}$, $0_{\times 1}$,

$m_\chi^2 L^2 : 16.2375_{\times 1}$, $7.90749_{\times 2}$, $7.29628_{\times 1}$, $7.27574_{\times 1}$, $6.18256_{\times 1}$,
  $5.89581_{\times 2}$, $5.50467_{\times 2}$, $5.49317_{\times 1}$, $4.78789_{\times 1}$, $4.25592_{\times 1}$,
  $3.87092_{\times 2}$, $3.00895_{\times 1}$, $2.47563_{\times 2}$, $2.03969_{\times 1}$, $1.89184_{\times 2}$,
  $1.82134_{\times 1}$, $1.71997_{\times 1}$, $1.64628_{\times 2}$, $1.29125_{\times 2}$, $1.21935_{\times 2}$,
  $1.20274_{\times 1}$, $0.983986_{\times 2}$, $0.938584_{\times 2}$, $0.893911_{\times 1}$, $0.587593_{\times 2}$,
  $0.562868_{\times 1}$, $0.439865_{\times 1}$, $0.371783_{\times 1}$, $0.346838_{\times 2}$, $0.303637_{\times 1}$,
  $0.294338_{\times 1}$, $0.262899_{\times 2}$, $0.236847_{\times 2}$, $0.0339378_{\times 2}$, $0.0286117_{\times 2}$,
  $0.0205378_{\times 1}$, $0.0192755_{\times 2}$, $0.0114180_{\times 1}$,

$m_\phi^2 L^2 : 6.67265_{\times 1}$, $5.70582_{\times 1}$, $1.71484_{\times 2}$, $1.67033_{\times 1}$, $1.37757_{\times 1}$,
  $0.666216_{\times 1}$, $0_{\times 27}$, $-0.0891377_{\times 2}$, $-0.547035_{\times 1}$, $-0.833421_{\times 2}$,
  $-0.907516_{\times 1}$, $-0.915646_{\times 1}$, $-1.14803_{\times 1}$, $-1.17006_{\times 2}$, $-1.29452_{\times 1}$,
  $-1.30728_{\times 1}$, $-1.35666_{\times 2}$, $-1.39437_{\times 2}$, $-1.64003_{\times 2}$, $-1.70815_{\times 2}$,
  $-1.74308_{\times 1}$, $-1.87815_{\times 2}$, $-1.96526_{\times 1}$, $-1.96573_{\times 2}$, $-2.06671_{\times 1}$,
  $-2.06900_{\times 2}$, $-2.06965_{\times 1}$, $-2.09083_{\times 1}$, $-2.09758_{\times 2}$, $-2.13338_{\times 2}$,
  $-2.18141_{\times 1}$,

P355983403.

$m_\psi^2 L^2 : 5.03505_{\times 1}$, $4.90092_{\times 1}$, $3.25015_{\times 1}$, $3.14370_{\times 1}$, $2.75155_{\times 1}$,
  $2.57142_{\times 1}$, $2.41902_{\times 1}$, $1.00004_{\times 1}$,

$m_A^2 L^2 : 7.25938_{\times 1}$, $7.20263_{\times 1}$, $7.10141_{\times 1}$, $6.95967_{\times 1}$, $6.35969_{\times 1}$,
  $5.98220_{\times 1}$, $5.78977_{\times 1}$, $5.68272_{\times 1}$, $5.22257_{\times 1}$, $5.06055_{\times 1}$,
  $4.92408_{\times 1}$, $4.73720_{\times 1}$, $4.40682_{\times 1}$, $4.27011_{\times 1}$, $4.17636_{\times 1}$,
  $3.97613_{\times 1}$, $2.79003_{\times 1}$, $2.68509_{\times 1}$, $1.44360_{\times 1}$, $1.36673_{\times 1}$,
  $1.09360_{\times 1}$, $0.968181_{\times 1}$, $0.863857_{\times 1}$, $0.673824_{\times 1}$, $0.670555_{\times 1}$,
  $0.394090_{\times 1}$, $0.367021_{\times 1}$, $0.00324705_{\times 1}$,

$m_\chi^2 L^2 : 20.1402_{\times 1}$, $19.6037_{\times 1}$, $13.0006_{\times 1}$, $12.5748_{\times 1}$, $11.0062_{\times 1}$,
  $10.4291_{\times 1}$, $10.2857_{\times 1}$, $10.1418_{\times 1}$, $9.87119_{\times 1}$, $9.67608_{\times 1}$,
  $9.42621_{\times 1}$, $9.41722_{\times 1}$, $8.96914_{\times 1}$, $8.74559_{\times 1}$, $8.74471_{\times 1}$,
  $8.60848_{\times 1}$, $8.05204_{\times 1}$, $7.63541_{\times 1}$, $7.46906_{\times 1}$, $7.37218_{\times 1}$,

$$7.00906_{\times 1}\,,\ 6.89305_{\times 1}\,,\ 5.00512_{\times 1}\,,\ 4.97228_{\times 1}\,,\ 4.87874_{\times 1}\,,$$
$$4.77513_{\times 1}\,,\ 4.28864_{\times 1}\,,\ 4.25789_{\times 1}\,,\ 4.23611_{\times 1}\,,\ 4.00016_{\times 1}\,,$$
$$3.98591_{\times 1}\,,\ 3.83188_{\times 1}\,,\ 3.74524_{\times 1}\,,\ 3.38312_{\times 1}\,,\ 3.25582_{\times 1}\,,$$
$$3.14876_{\times 1}\,,\ 3.00171_{\times 1}\,,\ 2.74757_{\times 1}\,,\ 2.64195_{\times 1}\,,\ 2.57394_{\times 1}\,,$$
$$2.42190_{\times 1}\,,\ 2.13557_{\times 1}\,,\ 2.13069_{\times 1}\,,\ 1.69644_{\times 1}\,,\ 1.65198_{\times 1}\,,$$
$$1.00783_{\times 1}\,,\ 0.867934_{\times 1}\,,\ 0.286209_{\times 1}\,,\ 0.276690_{\times 1}\,,\ 0.275490_{\times 1}\,,$$
$$0.216605_{\times 1}\,,\ 0.214997_{\times 1}\,,\ 0.138143_{\times 1}\,,\ 0.0910165_{\times 1}\,,\ 0.0803230_{\times 1}\,,$$
$$0.0000126900_{\times 1}\,,$$

$$m_\phi^2 L^2: 11.0147_{\times 1}\,,\ 10.4898_{\times 1}\,,\ 9.70105_{\times 1}\,,\ 8.39197_{\times 1}\,,\ 8.08150_{\times 1}\,,$$
$$7.65928_{\times 1}\,,\ 5.19712_{\times 1}\,,\ 4.95637_{\times 1}\,,\ 4.72816_{\times 1}\,,\ 4.35072_{\times 1}\,,$$
$$4.34468_{\times 1}\,,\ 4.31247_{\times 1}\,,\ 4.28617_{\times 1}\,,\ 4.00337_{\times 1}\,,\ 3.96357_{\times 1}\,,$$
$$3.79000_{\times 1}\,,\ 3.78372_{\times 1}\,,\ 3.65945_{\times 1}\,,\ 3.20239_{\times 1}\,,\ 2.87878_{\times 1}\,,$$
$$2.72982_{\times 1}\,,\ 2.66281_{\times 1}\,,\ 2.35844_{\times 1}\,,\ 2.25944_{\times 1}\,,\ 0.203476_{\times 1}\,,$$
$$0.186242_{\times 1}\,,\ 0_{\times 28}\,,\ -0.00336031_{\times 1}\,,\ -0.201939_{\times 1}\,,\ -1.18509_{\times 1}\,,$$
$$-1.19989_{\times 1}\,,\ -1.20241_{\times 1}\,,\ -1.31722_{\times 1}\,,\ -1.32040_{\times 1}\,,\ -1.48307_{\times 1}\,,$$
$$-1.60717_{\times 1}\,,\ -1.63632_{\times 1}\,,\ -1.99407_{\times 1}\,,\ -2.06215_{\times 1}\,,\ -2.24013_{\times 1}\,,$$
$$-2.24248_{\times 1}\,,\ -2.24659_{\times 1}\,,\ -2.24727_{\times 1}\,,$$

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