Localized objects in a 3-dimensional Chern-Simons matter model from a consistent truncation of 11-dimensional supergravity over $AdS_4 \times S^7/Z_k$

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Abstract

For 11-dimensional (11D) supergravity over $AdS_4 \times CP^3 \ltimes S^1/Z_k$, we include a new 4-form ansatz, composed mainly of the elements of the internal spcae. Solving the 11D supergarvity equations, we obtain a scalar Nonlinear Partial Differential Equation in Euclidean AdS_4 space. The resulting $SU(4) \times U(1)$-singlet (pseudo)scalars arise from probe (anti)M-branes wrapped around the internal space directions in the (Wick-rotated) skew-whiffed background; and the resulting anti-M2-branes theory breaks all 32 supersymmetries and parity of the original theory. Taking the backreaction on the external and internal spaces, the resulting bulk equations correspond to exactly marginal and marginally irrelevant boundary operators. Solving the equation, we write a closed solution for the massless ($m^2 = 0$) mode and an approximate solution for a massive mode ($m^2 = 40$) with math methods and especially the Adomian decomposition method, appropriate for near the boundary analyzes. The solutions have at least the $SO(4)$ symmetry and present instantons responsible for tunneling among almost degenerate vacua of the bulk Higgs-like scalar potential or true-vacuum bubbles growing from the false vacuum in the form of bounce solutions. To realize the bulk singlet (pseudo)scalars and in particular supersymmetry breaking, we excahnge the three fundamental representations for gravitino and as a result, we realize the wished singlet (pseudo)scalars in the spectrum after the branching of $SO(8) \rightarrow SU(4) \times U(1)$. As the same way, using the AdS_4/CFT_3 correspondence rules, by concentrating on the $U(1) \times U(1)$ part of the original quiver gauge group of the 3D boundary Chern-Simons matter (in fact, ABJM) theory, taking just a boundary scalar and a fermion field, introducing dual marginal ($\Delta_+ = 3$) and irrelevant ($\Delta_+ = 8$) boundary operators, and deforming the boundary action with them, we finally find exact solutions with finite actions which are in fact small instantons on a three-sphere with raduis at infinity. In addition, we confirm the bulk state-boundary operator correspondence in the leading order and match elements of the bulk and boundary solutions. Indeed, these solutions are instances of non-supersymmetric unstable AdS vacua with applications in early universe cosmology, inflationary models and tunnelings (here as collapsing vacuum bubbles leading to big-crunch singularities).

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