Nernst Branes in Gauged Supergravity

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IV Workshop on Black Holes

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Motivation

- Extremal black holes in string theory:

  detailed microscopic understanding available.

  Systems at $T = 0$ with $\mathcal{S} \neq 0$.

- What about black objects satisfying Nernst law?

  Systems at $T = 0$ with $\mathcal{S} = 0$.

  Of interest in AdS/CFT applications to condensed matter systems.

  Examples of Nernst configurations in *AdS* (with/without a dilaton field):

  `Goldstein et al, 0911.3586;`
  `D'Hoker and Kraus, 0911.4518`

- Systematics?

  Aim: Study Nernst brane configurations in the presence of fluxes in $D = 4, 5$.

  $N = 2$ $U(1)$ gauged supergravity. $(\Lambda \rightarrow V(Y))$

Extremal black branes in $D = 4$

$N = 2$ $U(1)$ gauged supergravity:

- prepotential $F(Y)$, complex scalar fields Y^I
- superpotential $W(Y) = h_I\, Y^I - h^I\, F_I$, dyonic fluxes (h_I, h^I)
- dyonic charges (q_I, p^I) $\quad I = 0, \ldots, n \quad , \quad U(1)^n$.

Static brane configurations:

- $ds^2 = -e^{2U}\, dt^2 + e^{-2U}\left(dr^2 + e^{2\psi}(dx^2 + dy^2)\right)$
  with $U = U(r)\,,\ \psi = \psi(r)\,,\ Y^I = Y^I(r)$
- Extremal: reduced Lagrangian in terms of squares of 'BPS' equations, in the presence of both charges and fluxes,

$$L_{red} = \int dr \left[\left(U' - \ldots\right)^2 - \left(\psi' - \ldots\right)^2 - \left(Y' - \ldots\right)^2 \right] + T.D.$$

- two additional constraints on solution to first-order flow equations: one is $\quad q_I\, h^I - p^I\, h_I = 0 \quad$ Hamiltonian constraint.
- Consistent with analysis for supersymmetric backgrounds `Dall'Agata + Gnecchi, arXiv:1012.375`

Flow equations

First-order flow equations for the scalars $Y^I(r)$: $\quad F_I = \partial F(Y)/\partial Y^I$

$$\begin{pmatrix} (Y^I - \bar{Y}^I)' \\ (F_I - \bar{F}_I)' \end{pmatrix} = -2i\,\mathrm{e}^{-\psi}\,\mathrm{Im}\begin{pmatrix} \mathrm{e}^{i\gamma}\,N^{IJ}\,(q_J - F_{JK}\,p^K) \\ \mathrm{e}^{i\gamma}\,\bar{F}_{IJ}\,N^{JK}\,(q_K - F_{KL}\,p^L) \end{pmatrix} + 2i\,\mathrm{e}^{\psi-2U}\,\mathrm{Re}\begin{pmatrix} \mathrm{e}^{i\gamma}\,N^{IJ}\,(h_J - F_{JK}\,h^K) \\ \mathrm{e}^{i\gamma}\,\bar{F}_{IJ}\,N^{JK}\,(h_K - F_{KL}\,h^L) \end{pmatrix} .$$

Reminiscent of attractor equations of ungauged supergravity ($h_I = h^I = 0$), but much more complicated to solve. Find:

- can construct $AdS_2 \times R^2$ backgrounds $\quad ((Y^I)' = 0)$;
- exact solutions in various models, for instance $F = -(Y^1)^3/Y^0$: interpolating solution between AdS_4 and $AdS_2 \times R^2$.
- STU-model: Nernst brane solutions ($T = 0, \mathcal{S} = 0$).

Nernst brane solutions

STU-model: $F = -Y^1 Y^2 Y^3 / Y^0$. 8 charges + 8 fluxes.
For simplicity, restrict to:

- axion free solutions;
- solution supported by electric $(q_0; h_1, h_2, h_3)$.

Near horizon solution ($r = 0$): only depends on charges and fluxes

- $e^{2U} = r^{5/2}\,,\; e^{2(\psi - U)} = r^{1/2}$, infinitely long throat with an unusual fall-off, vanishing area density;
  extremal solution with vanishing entropy density;
- scalar fields $S_2, T_2, U_2 = r^{-1/2}$;
  solution is a good solution in $D = 10$ sugra;

Asymptotically: unusual fall-off

$$e^{2U} = r^{3/2}\,,\; e^{2(\psi - U)} = r^{3/2} \quad , \quad S_2, T_2, U_2 = (C_0\, r)^{1/2}$$

Does not interpolate between AdS_4 and $AdS_2 \times R^2$. Unusual solution.

Work in progress

- Explore the space of Nernst solutions in $D = 4$.
- $D = 5$:
  - find class of extremal static solutions with $AdS_2 \times R^3$ horizons (constant scalars);
  - deformation (non-constant scalars);
  - Nernst solutions?

Thanks!