UNIVERSITÀ DEGLI STUDI DI MILANO

Black holes in gauged supergravity

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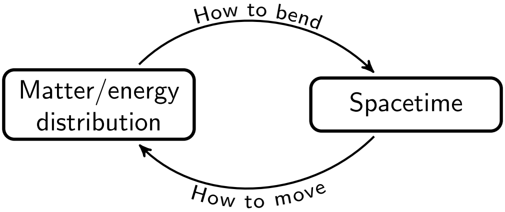
A brief warm up

General relativity

The interaction between bodies is described through a distortion of the spacetime, which is felt as gravity.



$$R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

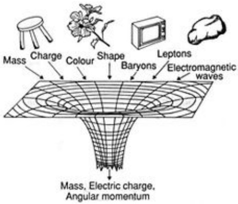
$$\frac{d^2 x^\rho}{d\tau^2} + \Gamma^\rho{}_{\mu\nu} \frac{dx^\mu}{d\tau} \frac{dx^\nu}{d\tau} = 0$$

In general relativity black holes are spacetime singularities.

No-hair theorem

The only electrovacuum solution topologically spherical, stationary, axisymmetric and asymptotically flat is the Kerr-Newman black hole.

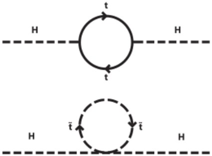
$\Longrightarrow$ Black holes are completely characterised by mass, angular momentum and total charge.



Supersymmetry

Why supersymmetry?

- Symmetry group containing the Poincaré group in a non-trivial way
- Symmetry between bosons and fermions
- Hierarchy problem ($\Delta m_H^2 \ll \Lambda_{UV}^2$)
- su(3), su(2) and u(1) coupling constants unification at high energy scales



Symmetry of the system ($\delta S = 0$) $\longrightarrow$ Conserved current ($\partial_\mu J^\mu_A = 0$)
Conserved charge ($\partial_t Q_A = 0$) $\longrightarrow$ Generator of the transformation ($[\epsilon^A Q_A, \phi] = i\delta_\epsilon \phi$)

In the case of SuSy the generators are the Weyl spinors Q_α for which

$$\{Q_\alpha, \bar{Q}_{\dot\beta}\} = 2(\sigma^\mu)_{\alpha\dot\beta} P_\mu$$

Invariance under local SuSy transformations $\Longrightarrow$ Invariance under local translations (diffeomorphisms)

$\Downarrow$ $\Downarrow$

Local supersymmetry $\Longrightarrow$ Supergravity

AdS/CFT

Correspondence between a d-dimensional conformal field theory and a $(d+1)$-dimensional gravitational theory with AdS vacuum.

$$\langle e^{\int_{\partial M} \phi_0(x)\hat{O}(x)dx} \rangle = e^{S_{AdS}[\phi|_{\partial M}=\phi_0]}$$

Fields in the AdS theory (ϕ) are dual to operators in the CFT ($\hat{O}$) and the correlation functions of the latter can be computed starting from the former.

- Connects different theories
- Strongly coupled field theory regime $\rightleftarrows$ Weak gravitational regime
- The information of the dynamics in AdS is stored on the boundary $\Longrightarrow$ it is an example of the realisation of the holographic principle

FI-gauged supergravity

The theory under exam is the $N = 2$, $D = 4$ gauged supergravity.

- It is a simple model
- It has the correct asymptotic behaviour to evade the no-hair theorem
- It has applications in the AdS/CFT correspondence; the presence of the scalar field breaks the conformal symmetry of the dual solution, which can happen in the CFT both explicitly and spontaneously
- It can be obtained from string compactifications $\Longrightarrow$ it is an effective theory describing the degrees of freedom at low energies

Field content

- 1 gravity multiplet (1 graviton, 2 gravitinos, 1 graviphoton)
- n_V vector multiplets (1 gauge field, 2 gauginos, 1 complex scalar)

We set to zero the fermionic fields, considering only a bosonic theory.

$N = 2$, $D = 4$ gauged supergravity (bosonic) action

$$S_{bos} = \int \left[\frac{R}{2} + \frac{1}{4} (\mathrm{Im}\,\mathcal{N})_{IJ} F^I_{\mu\nu} F^{J\mu\nu} - \frac{1}{4} (\mathrm{Re}\,\mathcal{N})_{IJ} {}^{\star}F^I_{\mu\nu} F^{J\mu\nu} + \right.$$
$$\left. - g_{\alpha\bar{\beta}} \partial_\mu z^\alpha \partial^\mu \bar{z}^{\bar{\beta}} - V(z^\alpha, \bar{z}^{\bar{\beta}}) \right] \sqrt{-g}\, d^4 x$$

In gauged supergravity the terms in the Lagrangian ($\mathcal{N}$, $g_{\alpha\bar{\beta}}$, V) are completely determined by the prepotential, a homogeneous function of degree two.
Two choices are taken into exam:

$$F(X) = \frac{i}{4} X^I \eta_{IJ} X^J \qquad \eta_{IJ} = \text{diag}(-,+,\dots,+)$$

$$F(X) = -\frac{(X^1)^3}{X^0} \qquad (t^3 \text{ model})$$

In both cases the solution is a rotating and supersymmetric black hole with Plebanski-Demianski-type metric

$$ds^2 = -\frac{Q}{W}(dt - p^2 dy)^2 + \frac{P}{W}(dt + q_1 q_2 dy)^2 + W\left(\frac{dq^2}{Q} + \frac{dp^2}{P}\right)$$

Thank you for your attention