

Unfolded Description of AdS_4 Black Hole

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Plan

- Introduction.

Motivation. Some important black hole properties. Unfolded formulation of dynamical systems.

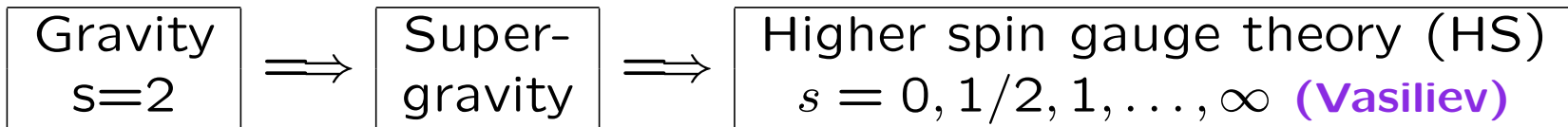
- AdS_4 space-time. Unfolded equations.

- AdS_4 black hole as the deformation of vacuum system.

- Integrating flow. Explicit coordinate independent BH metrics.

- Conclusion.

Motivation



HS gauge theory:

Consistent theory of interacting massless fields $s = 0, 1/2, \dots, \infty$ in *AdS* space-time

Current status:

Formulated at the level of equations of motion for all spins in $d = 4$ Bosonic version is known in any d



Lack of:

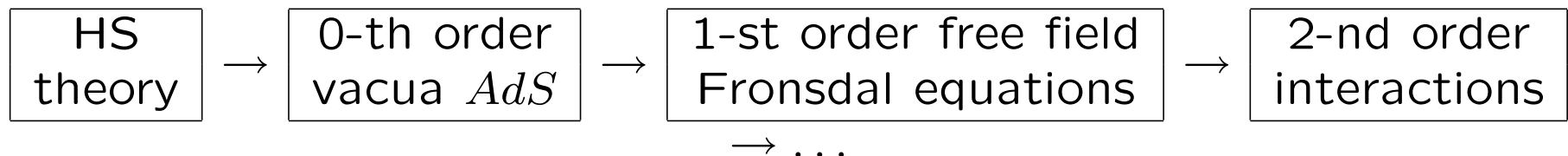
Action principle, quantization.



Obstacles:

1. HS does not have decoupled spin-2 sector \rightarrow all higher spins involved in the equations of motion.
2. The interval $ds^2 = g_{\mu\nu}dx^\mu dx^\nu$ is not gauge invariant quantity in higher spin algebra.
3. Considerable technical difficulties – the equations are essentially non-local involving space-time derivatives of all orders.

Perturbative analysis available



Classical black hole properties

Ex. $d = 4$ Kerr Solution

1. $g_{\mu\nu} = \eta_{\mu\nu}(x) + Mh_{\mu\nu}(x)$ – no $O(M^2)$ terms \implies Einstein equations reduce to **free** $s = 2$ Pauli-Fierz eqs.

$$\square h_{\mu\nu} - \partial_\mu \partial_\lambda h^\lambda{}_\nu - \partial_\nu \partial_\lambda h^\lambda{}_\mu = 0 \quad (h_{\mu}{}^\mu = 0)$$

2. $h_{\mu\nu} = \frac{1}{U(x)} k_\mu(x) k_\nu(x)$ – factorized form. k^μ – Kerr-Schild vector

$$k_\mu k^\mu = 0, \quad k^\mu D_\mu k_\nu = k^\mu \partial_\mu k_\nu = 0$$

3. BH provides Fronsdal fields $\phi_{\mu_1 \dots \mu_s} = \frac{M}{U} k_{\mu_1} \dots k_{\mu_s}$

$s = 0 \implies$ Klein-Gordon

$$\square \phi = 0$$

$s = 1 \implies$ Maxwell

$$\phi_\mu - \partial_\lambda \partial_\mu \phi^\lambda = 0$$

$s = 2 \implies$ Pauli-Fierz

$$\square \phi_{\mu\nu} - 2\partial_\lambda \partial_{(\mu} \phi_{\nu)}^\lambda = 0$$

$s = s \implies$ Fronsdal

$$\square \phi_{\mu_1 \dots \mu_s} - s\partial_\lambda \partial_{(\mu_1} \phi_{\mu_2 \dots \mu_s)}^\lambda = 0$$

4. Kerr-Schild presentation is also valid in AdS

$$g_{\mu\nu} = \eta_{\mu\nu}^{AdS}(x) + \frac{M}{U} k_\mu k_\nu, \quad k^\mu k_\mu = 0, \quad k^\mu \mathcal{D}_\mu k_\nu = k^\mu D_\mu k_\nu = 0$$

Just as well,

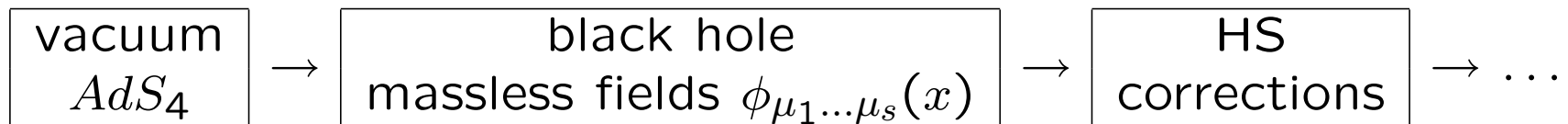
$$\phi_{\mu_1 \dots \mu_s} = \frac{M}{U} k_{\mu_1} \dots k_{\mu_s}$$

satisfies free massless spin- s equations (**Metsaev**) in AdS_4

$$\square \phi_{\mu_1 \dots \mu_s} - s D_\lambda D_{(\mu_1} \phi^\lambda_{\mu_2 \dots \mu_s)} = -2(s-1)(s+1)\lambda^2 \phi_{\mu_1 \dots \mu_s}$$

$\phi_{\mu_1 \dots \mu_s}(x)$ – **Black hole massless fields**

Program for HS black holes



Unfolded formulation

- First order coordinate independent differential equations (differential forms formalism)
- Assumes additional fields (generally infinitely many) that parameterize all on-shell derivatives of physical fields

Example: free massless scalar in Minkowski space-time $\square\phi(x) = 0$

Unfolding $\rightarrow \varphi(x), \quad \varphi_\mu = \partial_\mu\varphi, \quad \varphi_{\mu\nu} = \partial_\mu\varphi_\nu, \dots \quad \varphi_{\mu_1\dots\mu_n} = \partial_{\mu_1}\varphi_{\mu_2\dots\mu_n},$

...

Set of fields: $\phi, \quad \phi_\mu, \dots \quad \varphi_{\mu_1\dots\mu_n}, \dots$

Consistency condition: $\varphi_{\mu_1\dots\mu_n}$ – symmetric

Equations of motion: $\varphi^\mu{}_{\mu\mu_3\dots\mu_n} = 0$

To perform perturbative analysis of black holes in HS theory one has to have explicit expressions for all AdS_4 derivatives of AdS_4 -Kerr black hole fields (vierbein, curvature). Therefore, one needs AdS_4 covariant description of classical black hole to proceed.

Strategy

1. Find in pure AdS_4 space-time objects relevant to black hole such as Kerr-Schild vectors and blocks of BH curvature
2. Find appropriate deformation of AdS_4 equations that leads to BH
3. Find integrating flow with respect to deformation parameters mapping one system to another. Try to integrate flow equations with AdS_4 initial data

Cartan formalism

Instead of $g_{\mu\nu} \rightarrow$ Lorentz connection 1-form $\Omega_{[ab]} = \Omega_{[ab],\mu} dx^\mu$ and vierbein 1-form $h_a = h_{a,\mu} dx^\mu$, $a, b = 1, \dots, 4$

$$R_{ab} = d\Omega_{ab} + \Omega_a^c \wedge \Omega_{cb} \quad \text{Riemann 2-form}$$

$$R_a = dh_a + \Omega_a^b \wedge h_b = 0 \quad \text{torsion 2-form}$$

$$g_{\mu\nu} = h_{a,\mu} h_{b,\nu} \eta^{ab}$$

Two-component spinor notation

$V^a \rightarrow V^{\alpha\dot{\alpha}}$, $\alpha, \dot{\alpha} = 1, 2$, indices raised and lowered with $\epsilon_{\alpha\beta} = -\epsilon_{\beta\alpha}$

$$F_{ab} = -F_{ba} \rightarrow (F_{\alpha\alpha}, \bar{F}_{\dot{\alpha}\dot{\alpha}}), \quad C_{abcd} \text{ (Weyl tensor)} \rightarrow (C_{\alpha(4)}, \bar{C}_{\dot{\alpha}(4)})$$

$$R_{ab} \text{ (Ricci)} \rightarrow \Phi_{\alpha\dot{\alpha}\alpha\dot{\alpha}}$$

AdS_4 space-time (A)

$$ds^2 = -du^2 - dv^2 + dx^2 + dy^2 + dz^2, \quad -u^2 - v^2 + x^2 + y^2 + z^2 = \lambda^{-2}$$

Isometries: $o(3, 2) \implies 10$ Killing vectors. Let V^a be an AdS_4 Killing vector:

$$D_a V_b + D_b V_a = 0, \quad \kappa_{ab} = D_a V_b = -\kappa_{ba}$$

(Ricci identity: $D_a D_b V_c = R^d{}_{abc} V_d$)

$$D V_a = \kappa_{ab} h^b, \quad D \kappa_{ab} = \lambda^2 (V_a h_b - V_b h_a) \longleftarrow \text{unfolded equations}$$

$$d\Omega_{ab} + \Omega_a{}^c \wedge \Omega_{cb} = \lambda^2 h_a \wedge h_b, \quad dh_a + \Omega_a{}^b \wedge h_b = 0 \longleftarrow \text{consistency, } AdS_4$$

Spinor form for AdS_4 equations:

$$DV_{\alpha\dot{\alpha}} = \frac{1}{2}h^{\gamma\dot{\alpha}}\kappa_{\gamma\alpha} + \frac{1}{2}h_{\alpha}^{\dot{\gamma}}\bar{\kappa}_{\dot{\alpha}\dot{\gamma}}$$

$$D\kappa_{\alpha\alpha} = \lambda^2 h_{\alpha}^{\dot{\gamma}} V_{\alpha\dot{\gamma}}, \quad D\bar{\kappa}_{\dot{\alpha}\dot{\alpha}} = \lambda^2 h^{\gamma\dot{\alpha}} V_{\gamma\dot{\alpha}}.$$

Properties of the system (A)

1. AdS_4 covariant form

$$K_{AB} = K_{BA} = \begin{pmatrix} \lambda^{-1}\kappa_{\alpha\beta} & V_{\alpha\dot{\beta}} \\ V_{\beta\dot{\alpha}} & \lambda^{-1}\bar{\kappa}_{\dot{\alpha}\dot{\beta}} \end{pmatrix}, \quad \Omega_{AB} = \Omega_{BA} = \begin{pmatrix} \Omega_{\alpha\beta} & -\lambda h_{\alpha\dot{\beta}} \\ -\lambda h_{\beta\dot{\alpha}} & \bar{\Omega}_{\dot{\alpha}\dot{\beta}} \end{pmatrix} =$$

$$D_0 K_{AB} = 0, \quad D_0^2 \sim R_{0AB} = d\Omega_{AB} + \frac{1}{2}\Omega_A^C \wedge \Omega_{CB} = 0.$$

K_{AB} – AdS_4 global symmetry parameter

2. The existence of source-free Maxwell tensor

$$F_{\alpha\alpha} = -\lambda^{-2}G^3\kappa_{\alpha\alpha}, \quad \bar{F}_{\dot{\alpha}\dot{\alpha}} = -\lambda^{-2}\bar{G}^3\bar{\kappa}_{\dot{\alpha}\dot{\alpha}},$$

where

$$G = \frac{\lambda^2}{\sqrt{-\kappa^2}} = (-F^2)^{1/4}, \quad \bar{G} = \frac{\lambda^2}{\sqrt{-\bar{\kappa}^2}} = (-\bar{F}^2)^{1/4}$$

$F_{\alpha\alpha}$ and $\bar{F}_{\dot{\alpha}\dot{\alpha}}$ satisfy source free Maxwell equations and Bianchi identities

$$D_{\gamma\dot{\alpha}}F_{\alpha}{}^{\gamma} = 0, \quad D_{\alpha\dot{\gamma}}\bar{F}_{\dot{\alpha}}{}^{\dot{\gamma}} = 0.$$

*AdS*₄ Unfolded equations in terms of Maxwell field take the form:

$$DV_{\alpha\dot{\alpha}} = \frac{1}{2}\rho h^{\gamma}{}_{\dot{\alpha}}F_{\gamma\alpha} + \frac{1}{2}\bar{\rho} h_{\alpha}{}^{\dot{\gamma}}\bar{F}_{\dot{\alpha}\dot{\gamma}},$$

$$DF_{\alpha\alpha} = -\frac{3}{2G}h^{\beta\dot{\gamma}}V^{\beta}{}_{\dot{\gamma}}F_{(\beta\beta}F_{\alpha\alpha)}, \quad D\bar{F}_{\dot{\alpha}\dot{\alpha}} = -\frac{3}{2}h^{\gamma\dot{\beta}}V_{\gamma}{}^{\dot{\beta}}\bar{F}_{(\dot{\beta}\dot{\beta}}\bar{F}_{\dot{\alpha}\dot{\alpha})}.$$

with

$$\rho = -\lambda^2G^{-3}, \quad \bar{\rho} = -\lambda^2\bar{G}^{-3}.$$

3. Two first integrals

$$I_1 = V^2 - \frac{\lambda^2}{2} \left(\frac{1}{G^2} + \frac{1}{\bar{G}^2} \right),$$

$$I_2 = \frac{1}{G^3 \bar{G}^3} V^{\alpha\dot{\alpha}} V^{\alpha\dot{\alpha}} F_{\alpha\alpha} \bar{F}_{\dot{\alpha}\dot{\alpha}} - V^2 \left(\frac{1}{G^2} + \frac{1}{\bar{G}^2} \right) + \frac{\lambda^2}{4} \left(\frac{1}{G^2} - \frac{1}{\bar{G}^2} \right)^2,$$

$$dI_{1,2} = 0$$

related to two AdS_4 invariants (Casimir operators)

$$C_2 = \frac{1}{4} K_{AB} K^{AB} = I_1, \quad C_4 = \frac{1}{4} \text{Tr} K^4 = I_1^2 + \lambda^2 I_2$$

4. The existence of Kerr-Schild vectors

Introduce projectors

$$\Pi_{\alpha\beta}^{\pm} = \frac{1}{2}(\epsilon_{\alpha\beta} \pm \frac{1}{G^2} F_{\alpha\beta}), \quad \bar{\Pi}_{\dot{\alpha}\dot{\beta}}^{\pm} = \frac{1}{2}(\epsilon_{\dot{\alpha}\dot{\beta}} \pm \frac{1}{\bar{G}^2} \bar{F}_{\dot{\alpha}\dot{\beta}}).$$

The projectors allow one to build light-light vectors for any given vector $V_{\alpha\dot{\alpha}}$

real: $\xi_{\alpha\dot{\alpha}}^{+} = \Pi_{\alpha}^{+\beta} \bar{\Pi}_{\dot{\alpha}}^{+\dot{\beta}} V_{\beta\dot{\beta}}, \quad \xi_{\alpha\dot{\alpha}}^{-} = \Pi_{\alpha}^{-\beta} \bar{\Pi}_{\dot{\alpha}}^{-\dot{\beta}} V_{\beta\dot{\beta}}$

complex: $\xi_{\alpha\dot{\alpha}}^{+-} = \Pi_{\alpha}^{+\beta} \bar{\Pi}_{\dot{\alpha}}^{-\dot{\beta}} V_{\beta\dot{\beta}}, \quad \xi_{\alpha\dot{\alpha}}^{-+} = \Pi_{\alpha}^{-\beta} \bar{\Pi}_{\dot{\alpha}}^{+\dot{\beta}} V_{\beta\dot{\beta}}$

$$\xi_{\alpha\dot{\alpha}} \xi^{\alpha\dot{\alpha}} = 0$$

Kerr-Schild vectors:

$$\begin{aligned} k_{\alpha\dot{\alpha}} &= \frac{2}{(V^{+}V^{-})} V_{\alpha\dot{\alpha}}^{-}, & n_{\alpha\dot{\alpha}} &= \frac{2}{(V^{+}V^{-})} V_{\alpha\dot{\alpha}}^{+} \\ l_{\alpha\dot{\alpha}}^{-+} &= \frac{2}{(V^{+-}V^{-+})} V_{\alpha\dot{\alpha}}^{-+}, & l_{\alpha\dot{\alpha}}^{+-} &= \frac{2}{(V^{+-}V^{-+})} V_{\alpha\dot{\alpha}}^{+-} \end{aligned}$$

Kerr-Schild relations

$$e_{I,\alpha\dot{\alpha}} = (k_{\alpha\dot{\alpha}}, n_{\alpha\dot{\alpha}}, l_{\alpha\dot{\alpha}}^{+-}, l_{\alpha\dot{\alpha}}^{-+})$$

$$e_{I,\alpha\dot{\alpha}} e_{I,\alpha\dot{\alpha}}^{\alpha\dot{\alpha}} = 0, \quad \frac{1}{2} e_{I,\alpha\dot{\alpha}} V^{\alpha\dot{\alpha}} = 1,$$

$$e_I^{\alpha\dot{\alpha}} D_{\alpha\dot{\alpha}} e_{I,\beta\dot{\beta}} = 0 \quad (\text{no summation over } I)$$

Towards black hole

1. **Black hole Weyl tensor is of D-Petrov type i.e., $C_{\alpha(4)} \sim F_{\alpha\alpha} F_{\alpha\alpha}$**
2. **Has at least two Killing vectors**
3. **Metric admits Kerr-Schild vector**

Deformation of $AdS_4 \rightarrow$ black hole unfolded system (B)

(Keep the same form of the unfolded equations)

$$\mathcal{D}\mathcal{V}_{\alpha\dot{\alpha}} = \frac{1}{2}\rho \mathbf{h}^{\gamma\dot{\alpha}} \mathcal{F}_{\gamma\alpha} + \frac{1}{2}\bar{\rho} \mathbf{h}_{\alpha\dot{\gamma}} \bar{\mathcal{F}}_{\dot{\alpha}\dot{\gamma}},$$

$$\mathcal{D}\mathcal{F}_{\alpha\alpha} = -\frac{3}{2\mathcal{G}} \mathbf{h}^{\beta\dot{\gamma}} \mathcal{V}_{\dot{\gamma}\beta} \mathcal{F}_{(\beta\beta} \mathcal{F}_{\alpha\alpha)},$$

$$\mathcal{D}\bar{\mathcal{F}}_{\dot{\alpha}\dot{\alpha}} = -\frac{3}{2\bar{\mathcal{G}}} \mathbf{h}^{\gamma\dot{\beta}} \mathcal{V}_{\gamma\dot{\beta}} \bar{\mathcal{F}}_{(\dot{\beta}\dot{\beta}} \bar{\mathcal{F}}_{\dot{\alpha}\dot{\alpha}})$$

Unlike the AdS_4 case with $\rho = -\lambda^2 \mathcal{G}^{-3}$ we assume ρ to be arbitrary $\rho = \rho(\mathcal{G}, \bar{\mathcal{G}})$

Bianchi identities: $\mathcal{D}^2 \sim \mathbf{R}$, $\mathcal{D}\mathbf{R} = 0$

fix $\rho(\mathcal{G}, \bar{\mathcal{G}})$ uniquely in the form

$$\rho(\mathcal{G}, \bar{\mathcal{G}}) = \mathcal{M} - \lambda^2 \mathcal{G}^{-3} - \mathbf{q} \bar{\mathcal{G}}$$

Curvature 2-form is given by

$$\mathcal{R}_{\alpha\alpha} = \frac{\lambda^2}{2} \mathbf{H}_{\alpha\alpha} - \frac{3(\mathcal{M} - \mathfrak{q}\bar{\mathcal{G}})}{4\mathcal{G}} \mathbf{H}^{\beta\beta} \mathcal{F}_{(\beta\beta} \mathcal{F}_{\alpha\alpha)} + \frac{\mathfrak{q}}{4} \bar{\mathbf{H}}^{\dot{\beta}\dot{\beta}} \bar{\mathcal{F}}_{\dot{\beta}\dot{\beta}} \mathcal{F}_{\alpha\alpha}, \quad \mathbf{H}_{\alpha\alpha} = h_{\alpha}^{\dot{\alpha}} \wedge h_{\alpha\dot{\alpha}}$$

AdS₄-Kerr-Newman-Taub-NUT black hole (rotated, EM and NUT-charged)

M=ReM – black hole mass

N=ImM– NUT charge

q = e² + g² – sum of squared electric and magnetic charges

Properties of the system (B)

1. Two integrals of motion

$$\mathcal{I}_1 = \mathcal{V}^2 - \mathcal{M}\mathcal{G} - \bar{\mathcal{M}}\bar{\mathcal{G}} - \frac{\lambda^2}{2} \left(\frac{1}{\mathcal{G}^2} + \frac{1}{\bar{\mathcal{G}}^2} \right) + \mathfrak{q}\mathcal{G}\bar{\mathcal{G}},$$

$$\mathcal{I}_2 = \frac{1}{\mathcal{G}^3\bar{\mathcal{G}}^3} \mathcal{V}^{\alpha\dot{\alpha}} \mathcal{V}^{\alpha\dot{\alpha}} \mathcal{F}_{\alpha\alpha} \bar{\mathcal{F}}_{\dot{\alpha}\dot{\alpha}} - 2 \left(\frac{\mathcal{M}}{\mathcal{G}} + \frac{\bar{\mathcal{M}}}{\bar{\mathcal{G}}} \right) - \mathcal{I}_1 \left(\frac{1}{\mathcal{G}^2} + \frac{1}{\bar{\mathcal{G}}^2} \right) - \frac{\lambda^2}{4} \left(\frac{1}{\mathcal{G}^4} + \frac{1}{\bar{\mathcal{G}}^4} \right) - \frac{3\lambda^2}{2\mathcal{G}^2\bar{\mathcal{G}}^2}$$

2. $\mathcal{F}_{\alpha\alpha}, \bar{\mathcal{F}}_{\dot{\alpha}\dot{\alpha}}$ form source free Maxwell tensor

$$\mathcal{D}_{\alpha\dot{\gamma}}\bar{\mathcal{F}}_{\dot{\alpha}}^{\dot{\gamma}} = 0, \quad \mathcal{D}_{\gamma\dot{\alpha}}\mathcal{F}^{\alpha\gamma} = 0$$

3. admits two real and two complex Kerr-Schild vectors

real: $k_{\alpha\dot{\alpha}} = \frac{2}{(V+V^-)}V_{\alpha\dot{\alpha}}^-, \quad n_{\alpha\dot{\alpha}} = \frac{2}{(V+V^-)}V_{\alpha\dot{\alpha}}^+$

complex: $l_{\alpha\dot{\alpha}}^{-+} = \frac{2}{(V+-V-+)}V_{\alpha\dot{\alpha}}^{-+}, \quad l_{\alpha\dot{\alpha}}^{+-} = \frac{2}{(V+-V-+)}V_{\alpha\dot{\alpha}}^{+-}$

Systems (A) and (B) are algebraically similar in many respects and coincide at $\mathcal{M} = q = 0$ describing empty AdS_4 space-time \Rightarrow map to $\mathcal{M}, q \neq 0??$

Integrating flow (A) \Leftrightarrow (B)

Let the deformation parameters $\chi = (\mathcal{M}, \bar{\mathcal{M}}, \mathbf{q})$ run \Rightarrow one has corresponding flows $\frac{\partial}{\partial \chi}$. **Applying the integrability conditions to (B):**

$$[d, \frac{\partial}{\partial \chi}] = [\frac{\partial}{\partial \chi}, \frac{\partial}{\partial \chi'}] = 0$$

Example:

$$\partial_{\mathcal{M}} \mathcal{V}_{\alpha\dot{\alpha}} = \sum_{I=1}^4 \phi_I \hat{e}_{I, \alpha\dot{\alpha}}, \quad \partial_{\mathcal{M}} \mathbf{h}_{\alpha\dot{\alpha}} = \frac{1}{2} \sum_{I=1}^4 \phi_I \hat{e}_{I, \alpha\dot{\alpha}} \hat{e}_{I, \beta\dot{\beta}} \mathbf{h}^{\beta\dot{\beta}}, \quad \partial_{\chi} \mathcal{F}_{\alpha\alpha} = 0,$$

where

$$\begin{aligned} \phi_1 &= \frac{\mathcal{G} + \bar{\mathcal{G}}}{4} \alpha_1(r), & \phi_2 &= \frac{\mathcal{G} + \bar{\mathcal{G}}}{4} \alpha_2(r), \\ \phi_3 &= \frac{\mathcal{G} - \bar{\mathcal{G}}}{4} \beta_1(y), & \phi_4 &= \frac{\mathcal{G} - \bar{\mathcal{G}}}{4} \beta_2(y) \end{aligned}$$

and

$$r = \operatorname{Re} \frac{1}{\mathcal{G}}, \quad y = \operatorname{Im} \frac{1}{\mathcal{G}}, \quad \alpha_1 + \alpha_2 = \beta_1 + \beta_2 = 1$$

Integration

Kerr-Schild vectors:

$$\begin{aligned}\hat{k}_{\alpha\dot{\alpha}} &= k_{\alpha\dot{\alpha}} \left(\frac{\Delta_r}{\hat{\Delta}_r} \right)^{\alpha_2}, & \hat{n}_{\alpha\dot{\alpha}} &= n_{\alpha\dot{\alpha}} \left(\frac{\Delta_r}{\hat{\Delta}_r} \right)^{\alpha_1}, \\ \hat{l}_{\alpha\dot{\alpha}}^{+-} &= l_{\alpha\dot{\alpha}}^{+-} \left(\frac{\Delta_y}{\hat{\Delta}_y} \right)^{\beta_2}, & \hat{l}_{\alpha\dot{\alpha}}^{-+} &= l_{\alpha\dot{\alpha}}^{-+} \left(\frac{\Delta_y}{\hat{\Delta}_y} \right)^{\beta_1},\end{aligned}$$

where

$$\hat{\Delta}_r = 2Mr + r^2(\lambda^2 r^2 + \mathcal{I}_1) + \frac{1}{2}(-\mathbf{q} + \frac{\mathcal{I}_2}{2})$$

$$\hat{\Delta}_y = 2Ny + y^2(\lambda^2 y^2 - \mathcal{I}_1) + \frac{1}{2}(\mathbf{q} + \frac{\mathcal{I}_2}{2}),$$

and

$$\Delta_{r,y} = \hat{\Delta}_{r,y} \Big|_{\mathcal{M}, \overline{\mathcal{M}}, \mathbf{q}=0}, \quad e_{I,\alpha\dot{\alpha}} = \hat{e}_{I,\alpha\dot{\alpha}} \Big|_{\mathcal{M}, \overline{\mathcal{M}}, \mathbf{q}=0}.$$

Black hole metrics

- **General case (Carter-Plebanski)**

deformation parameters: M – black hole mass, N – NUT charge, q – EM charges

first integrals parameters: ϵ – Carter constant, a – angular momentum

$$ds^2 = ds_0^2 + \frac{2Mr - q/2}{r^2 + y^2}(\alpha_1(r)K + \alpha_2(r)N)^2 - \frac{2Ny + q/2}{r^2 + y^2}(\beta_1(y)L^{+-} + \beta_2(y)L^{-+})^2$$

$$+ 4\alpha_1(r)\alpha_2(r)\frac{r^2 + y^2}{\Delta_r \hat{\Delta}_r}(2Mr - q/2)dr^2 - 4\beta_1(y)\beta_2(y)\frac{r^2 + y^2}{\Delta_y \hat{\Delta}_y}(2Ny + q/2)dy^2,$$

where

$$K = k_\mu dx^\mu, \quad N = n_\mu dx^\mu, \quad L^{+-} = l_\mu^{+-} dx^\mu, \quad L^{-+} = l_\mu^{-+} dx^\mu$$

and kinematical parameters ϵ, a are expressed via AdS_4 Casimir invariants

$$\epsilon = C_2, \quad 4\lambda^2 a^2 = C_4 - C_2^2$$

- **Kerr-Newman case** (rotated and charged black hole)

$$ds^2 = ds_0^2 + \frac{2Mr - \frac{q^2}{2}}{r^2 + y^2} k_\mu k_\nu dx^\mu dx^\nu .$$

$$C_2 = 1 + \lambda^2 a^2, \quad C_4 = C_2^2 + 4\lambda^2 a^2 .$$

- **Reissner-Nordström** (static charged black hole)

$$C_4 = C_2^2 \neq 0, \quad (K_A^C K_C^B \sim \delta_A^B)$$

Conclusion

- It is shown that a wide class of black hole metrics (Carter-Plebanski) admits simple unfolded description in terms of Killing and source-free Maxwell fields. The system is obtained as a parametric deformation of AdS_4 global symmetry equation. Two deformation parameters $\mathcal{M} \in \mathbb{C}$ and $\mathbf{q} \in \mathbb{R}$ are associated with black hole mass $\mathbf{M} = \text{Re } \mathcal{M}$, NUT charge $\mathbf{N} = \text{Im } \mathcal{M}$ and electro-magnetic charges $\mathbf{q} = e^2 + g^2$. Black hole kinematic characteristics related to the angular momentum a and the Carter parameter ϵ are expressed via two first integrals of the unfolded system

- Type of a black hole whether it is rotated or static is defined by the values of AdS_4 invariants (Casimir operators). In particular static black hole is defined by

$$C_4 = C_2^2$$

- The proposed formulation gives rise to a coordinate independent description of the black hole metric in AdS_4

- Black hole Fronsdal fields result as a simple consequence in the unfolded system