

gravitace

$$g_{mn} \rightarrow \nabla_n \rightarrow R_{mn}{}^k{}_l$$

$$S_{GR}[g] = \frac{1}{2\kappa} \int_{\Omega} (R - 2\Lambda) g^{-\frac{1}{2}}$$

$$S = S_{GR} + S_{scat}(\dots, g)$$

$$\frac{\delta S}{\delta g} = 0 \quad \frac{\delta}{\delta g^{\mu\nu}} \frac{\delta S_{GR}}{\delta g^{\mu\nu}} = -\frac{1}{2\kappa} (\text{Ric} - \frac{1}{2} Rg + \Lambda g)$$

$$\text{Ric} - \frac{1}{2} Rg + \Lambda g = \kappa T \quad \nabla_m T^{mn} = 0$$

$$T = -\frac{2}{\kappa g^{\mu\nu}} \frac{\delta S_{scat}}{\delta g^{\mu\nu}}$$

$$g \rightarrow g + \delta g \quad \delta g_{mn} = \nabla_{(m} \xi_{n)} \quad \delta S_{GR} = \int \frac{\delta S_{GR}}{\delta g} \delta g$$

skal. pole

$$\phi(x) \quad d\phi$$

$$S_{SP}[\phi, g] = -\frac{1}{2} \int_{\Omega} (d\phi \cdot g^{\mu\nu} d\phi + m^2 \phi^2) g^{-\frac{1}{2}}$$

$$S_{SPI}[\phi, g] = - \int_{\Omega} U(\phi) g^{-\frac{1}{2}}$$

$$S[\phi, g] = -\frac{\kappa}{2} \int_{\Omega} R \phi^2 g^{-\frac{1}{2}}$$

$$\frac{\delta S_{SP}}{\delta \phi} = -g^{-\frac{1}{2}} \left[\underbrace{-\square + m^2}_{\nabla_{\mu} g^{\mu\nu} \nabla_{\nu}} \right] \phi$$

$$\frac{1}{g^{-\frac{1}{2}}} \frac{\delta S_{scat}}{\delta \phi} = \left[-\square + m^2 \right] \phi = \mathcal{J}$$

$$T_{SP} = d\phi d\phi - \frac{1}{2} g (d\phi \cdot g^{\mu\nu} d\phi + m^2 \phi^2)$$

kalibrační a látková pole

GM

lokální kal. grupa

gM

lokální kal. algebra

$C_{\mu\nu}{}^{\kappa}{}_{\lambda}$ $K_{\alpha\beta}$

D

kalibrační pol

kov. der. na gM $Dc = 0$

AM

asoc. vekt. bundl

$$T_{\mu\nu}{}^A \quad t_{m\nu}{}^A = m^{\alpha} t_{\alpha}{}^A{}_{\nu}$$

$H_{\alpha\beta}$ metra. (ob. součin)

$$t_{m\nu}{}^+ = -t_{m\nu}{}^-$$

látková pol $\in \text{Vect AM}$

Φ^A

gravitace

$$g_{mn} \rightarrow \nabla_m \rightarrow R_{mn}{}^k{}_l$$

$$S_{GR}[g] = \frac{1}{2\kappa} \int (R - 2\Lambda) g^{\frac{1}{2}}$$

$$S_f = S_{GR} + S_{mat}(\dots, g)$$

$$\frac{\delta S}{\delta g} = 0 \quad \frac{\delta S_{GR}}{\delta g^{\mu\nu}} = -\frac{1}{2\kappa} (\text{Ric} - \frac{1}{2} Rg + \Lambda g)$$

$$\text{Ric} - \frac{1}{2} Rg + \Lambda g = \kappa T \quad \nabla_m T^{mn} = 0$$

$$T = -\frac{1}{2\kappa} \frac{\delta S_{mat}}{\delta g^{\mu\nu}}$$

$$g \rightarrow g + \delta g \quad \delta g_{mn} = \nabla_m \xi_n \quad \delta S_{GR} = \int \frac{\delta S_{GR}}{\delta g^{\mu\nu}} \delta g^{\mu\nu}$$

Skal. pole

$$\phi(x) \quad d_m \phi$$

$$S_{SP}[\phi, g] = -\frac{1}{2} \int_{\Omega} (d_m \phi g^{mn} d_n \phi + m^2 \phi^2) g^{\frac{1}{2}}$$

$$S_{SPI}[\phi, g] = - \int_{\Omega} U(\phi) g^{\frac{1}{2}}$$

$$S[\phi, g] = -\frac{\xi}{2} \int_{\Omega} R \phi^2 g^{\frac{1}{2}}$$

$$\frac{\delta S_{SP}}{\delta \phi} = -g^{\frac{1}{2}} \left[\underbrace{-\square}_{\nabla_m g^{mn} \nabla_n} + m^2 \right] \phi$$

$$\frac{1}{g^{\frac{1}{2}}} \frac{\delta S_{SP}}{\delta \phi} = \square \left[-\square + m^2 \right] \phi = \square$$

$$T_{SP} = d\phi d\phi - \frac{1}{2} g (d\phi \cdot g^{-1} \cdot d\phi + m^2 \phi^2)$$

Kalibracím a lätzková pl

$G M$ lokalní kal. grupa

$g M$ lokalní kal. algebra

$$C_{M^k} \cong K_{\alpha\beta}$$

D kalibracím pl

kov. der. na $g M$ $Dc = 0$

$A M$ asoc. metr. bundl

$$T_{\alpha\beta}^A \quad t_{m\beta}^A = m^\alpha t_{\alpha\beta}^A$$

$H_{\alpha\beta}$ metr. (sk. součin)

$$t_m^+ = -t_m$$

Φ^A

lätzková pl $\in \text{Vect } A M$

Kalibracimí pole

trivializace E_A^H ∂

$$D_m m^{\mu} = \partial_m m^{\mu} + [\Omega_m, m]^{\mu}$$

$$\Omega_m^{\mu} = \partial_m \Omega^{\mu} + [\Omega_m, \Omega]^{\mu}$$

$$D_m \wedge D_n m^{\mu} = [F_{mn}, m]^{\mu}$$

$$S_{KP}[D, g] = -\frac{1}{4} \epsilon_{KP} \int F_{mn}^{\mu} F_{rs}^{\nu} k_{\mu\nu}^{\lambda} g^{\lambda\rho} g^{\sigma\tau} g^{\alpha\beta} \dots$$

$$\frac{\delta S}{\delta D_m^{\mu}} = \sum_{KP} k_{\mu\nu}^{\lambda} g^{\lambda\rho} (D_K F_{\rho L}^{\nu}) g^{\sigma\tau} g^{\alpha\beta}$$

$$\frac{1}{g^2} \frac{\delta S}{\delta D_m^{\mu}} = \int_{KP} g^{\lambda\rho} (D_K F_{\rho L}^{\nu}) = \int_{SK} J_{\mu}^{\nu}$$

$$D \wedge F = 0 \quad D_m J_{\mu}^{\nu} = 0$$

$$T_{mn} = \epsilon_{kp} \left[F_{mk}^{\mu} F_{nl}^{\nu} k_{\mu\nu}^{\lambda} g^{\lambda\rho} - \frac{1}{4} g_{mn} F_{ab}^{\mu} F_{cd}^{\nu} k_{\mu\nu}^{\lambda} g^{\lambda\rho} g^{\sigma\tau} \right]$$

látkové pole

$$D_m a g^M \rightarrow m a A^M$$

$$D_m t_{\mu}^{\nu} = 0 \quad D_m H_{AB} = 0$$

$$S_{YM}[\Phi, D, g] = -\frac{1}{2} \int (D_m \Phi^A D_n \Phi^B H_{AB} g^{mn} + M^2 \Phi^A \Phi^B H_{AB}) g^{\mu\nu}$$

$$\frac{\delta S_{YM}}{\delta \Phi^A} = -g^{-1} (-g^{mn} D_m D_n \Phi^B + M^2 \Phi^B) H_{AB}$$

$$\frac{1}{g^2} \frac{\delta S_{YM}}{\delta \Phi^A} = J_{SP}^A \quad [-g^{mn} D_m D_n + M^2] \Phi^A = J_{SP}^A$$

$$J_{KP}^{\mu} = -t_{K}^{\mu} \Phi^{\nu} D_n \Phi^{\lambda} H_{\mu\nu} g^{\lambda\rho}$$

$$T_{mn} = D_n \Phi^A D_o \Phi^B H_{AB} - \frac{1}{2} g_{mn} (D_K \Phi^A D_L \Phi^B H_{AB} g^{\lambda\rho} + M^2 \Phi^A \Phi^B H_{AB})$$

Kalibracimí a látkové pole

GM lokální kal. grupa

gM lokální kal. algebra

$$C_{\mu\nu}^{\lambda} \quad k_{\mu\nu}^{\lambda}$$

D kalibracimí pol

kov. der $m \in gM \quad Dc = 0$

AM asoc. vektor. bundl

$$T_{\mu\nu}^A \quad t_{m\nu}^A = m^{\alpha} t_{\alpha\nu}^A$$

H_{AB} metra. (sk. součin)

$$t_m^{\dagger} = -t_m$$

látkové pl \in Sect AM

$$\Phi^A$$

$$A_{\mu}^{\nu} = \Omega_{\mu}^{\nu} t_{\mu}^{\nu}$$

Kalibrirani pole

trivializace $E_A^H \quad \odot$

$$D_{\bar{m}} m^{\bar{r}} = \partial_{\bar{m}} m^{\bar{r}} + [\mathcal{A}_{\bar{m}}, m]^{\bar{r}}$$

$$\mathcal{F}_{\bar{m}}^{\bar{r}} \quad \hat{\mathcal{F}}_{\bar{m}\bar{n}}^{\bar{r}} = \partial_{\bar{m}} \mathcal{A}_{\bar{n}}^{\bar{r}} - \partial_{\bar{n}} \mathcal{A}_{\bar{m}}^{\bar{r}} + [\mathcal{A}_{\bar{m}}, \mathcal{A}_{\bar{n}}]^{\bar{r}}$$

$$D_{\bar{m}} \wedge D_{\bar{n}} m^{\bar{r}} = [\hat{\mathcal{F}}_{\bar{m}\bar{n}}, m]^{\bar{r}}$$

$$S_{\text{KP}}[D, g] = -\frac{1}{4} \varepsilon_{\text{KP}} \int_{D \wedge \mathbb{R}^4} \hat{\mathcal{F}}_{\bar{m}\bar{n}}^{\bar{r}} \hat{\mathcal{F}}_{\bar{k}\bar{l}}^{\bar{s}} k_{\bar{r}\bar{s}} g_{\bar{m}\bar{k}}^{\bar{p}} g_{\bar{n}\bar{l}}^{\bar{q}} g_{\bar{p}\bar{q}}$$

$$\frac{\delta S_{\text{KP}}}{\delta D_{\bar{m}}^{\bar{r}}} = \varepsilon_{\text{KP}} k_{\bar{r}\bar{s}} g_{\bar{m}\bar{n}}^{\bar{p}} (D_{\bar{k}} \hat{\mathcal{F}}_{\bar{l}\bar{p}}^{\bar{r}}) g_{\bar{s}\bar{q}}^{\bar{t}} g_{\bar{t}\bar{q}}$$
$$\frac{1}{g_{\bar{m}\bar{n}}^{\bar{p}}} \frac{\delta S_{\text{KP}}}{\delta D_{\bar{m}}^{\bar{r}}} = \int_{\text{KP}}^{\bar{m}} g_{\bar{r}\bar{s}}^{\bar{t}} (D_{\bar{k}} \hat{\mathcal{F}}_{\bar{l}\bar{p}}^{\bar{r}}) = \frac{1}{\varepsilon_{\text{KP}}} \int_{\bar{m}}^{\bar{r}}$$

$$D \wedge \hat{\mathcal{F}} = 0 \quad D_{\bar{m}} \int_{\bar{r}}^{\bar{m}} = 0$$

$$T_{\bar{m}\bar{n}} = \varepsilon_{\text{KP}} \left[\hat{\mathcal{F}}_{\bar{m}\bar{k}}^{\bar{r}} \hat{\mathcal{F}}_{\bar{n}\bar{l}}^{\bar{s}} k_{\bar{r}\bar{s}} g_{\bar{m}\bar{k}}^{\bar{p}} - \frac{1}{4} g_{\bar{m}\bar{n}} \hat{\mathcal{F}}_{\bar{a}\bar{b}}^{\bar{r}} \hat{\mathcal{F}}_{\bar{c}\bar{d}}^{\bar{s}} k_{\bar{r}\bar{s}} g_{\bar{a}\bar{c}}^{\bar{p}} g_{\bar{b}\bar{d}}^{\bar{q}} \right]$$

l'atkové pole

D na $gM \rightarrow$ na ATM

$$D_{\underline{m}} t_{\underline{m}}^{\underline{A}} = 0 \quad D_{\underline{m}} H_{\underline{AB}} = 0$$

$$S_{YM}[\Phi, D, g] = -\frac{1}{2} \int (D_{\underline{m}} \Phi^{\underline{A}} D_{\underline{n}} \Phi^{\underline{B}} H_{\underline{AB}} g^{\underline{mn}} + M^2 \Phi^{\underline{A}} \Phi^{\underline{B}} H_{\underline{AB}}) \mathcal{G}^{\frac{1}{2}}$$

$$\frac{\delta S_{YM}}{\delta \Phi^{\underline{A}}} = -g^{\frac{1}{2}} (-g^{\underline{mn}} D_{\underline{m}} D_{\underline{n}} \Phi^{\underline{B}} + M^2 \Phi^{\underline{B}}) H_{\underline{BA}}$$

$$\frac{1}{g^{\frac{1}{2}}} \frac{\delta S_{out}}{\delta \Phi^{\underline{A}}} = J_{SP, \underline{A}} \quad [-g^{\underline{mn}} D_{\underline{m}} D_{\underline{n}} + M^2] \Phi^{\underline{A}} = J_{SP}^{\underline{A}}$$

$$J_{KP, \underline{K}} = -t_{\underline{K}}^{\underline{M}} \Phi^{\underline{K}} D_{\underline{n}} \Phi^{\underline{N}} H_{\underline{MN}} g^{\underline{mn}}$$

$$A_{\underline{m}}^{\underline{K}} = \mathcal{L}_{\underline{m}} t_{\underline{K}}^{\underline{K}}$$

$$T_{\underline{mn}} = D_{\underline{K}} \Phi^{\underline{A}} D_{\underline{L}} \Phi^{\underline{B}} H_{\underline{AB}} - \frac{1}{2} g_{\underline{mn}} (D_{\underline{K}} \Phi^{\underline{A}} D_{\underline{L}} \Phi^{\underline{B}} H_{\underline{AB}} g^{\underline{KL}} + M^2 \Phi^{\underline{A}} \Phi^{\underline{B}} H_{\underline{AB}})$$