

# Advanced general relativity

## 1 Auxiliary fields

- 1.1 Generalized auxiliary fields and symmetries  $\delta/\delta\phi, \mathbb{L}$ , symmetry
- 1.2 Invertibility and Legendre transforms

## p5 2 Gauge symmetry

- 2.1 Intro  $R^i{}_\alpha[L^\alpha]$
- 2.2 Mathematical tools  $p$ -form,  $d, \star$ , Poincaré lemma
- 2.3 Noether current  $f, kI$
- 2.4 Linearised gauge theories  $L^{(2)}, \bar{L}^\alpha$

## p13 3 Application to EFE

- 3.1 Metric formulation  $S_{EH}, \{f\}, T_{ab}, f_{fg}$

## 4 Cartan formulation

- 4.1 Mathematical reminders

- lin. algebra Spectral thm, Sylvester, Polar and QR decomposition
- Manifolds and jets: topo. space, manifold,  $C^\infty$ ,  $T_p M$ ,  $\mathcal{X}, [f], \text{Jacobi}$
- Non. coord. basis:  $e_a^\mu, \Lambda \in GL(n, \mathbb{R})$
- Covector  $V^*, \otimes^a$
- Change of basis  $T_p^* M$
- Tensor algebra  $\mathcal{R}, (p)$
- Metric  $g, g_{ab}$ , signature  $(s, t)$
- Exterior algebra  $\mathcal{R}^p(V), \wedge, [e_a, e_b], d$
- Affine connection // transport,  $\nabla, \Gamma^a{}_b$
- Torsion tensor and affine co.  $T, T^a{}_c, T^c{}_b, d\omega$
- Levi-Civita co.  $\{p^a{}_b\}$ , Fund. thm of geo diff
- Lorentz co.  $\Gamma^a{}_{bc}, K^a{}_{bc}, \bar{\Gamma}^a{}_{bc}, \kappa^a{}_{bc}, \Gamma^a{}_b{}_\mu$
- Curvature  $R, R^a{}_b, R$
- $GL(n, \mathbb{R})$  algebra, Bianchi, Poincaré algebra

- 4.2 Cartan's action  $S^c, \nabla/\nabla', G^a{}_\mu, R^a{}_\mu$

- 4.3 Einstein-Dirac theory  $S^{ED}$

- 4.4 Gravity as a Chern-Simons theory  $S^c$