# Generalized Holst action with topological terms

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# Motivation

**Action principle** Well defined (under appropiate boundary conditions)

- Finite
- Differentiable

**Topological terms** Can be considered, per se, as a theory that has no local degrees of freedom, but it may have global degrees associated with the non-trivial topology of the manifold in which they are defined.

**Generalized Holst action $+$ Topological Terms** How this boundary terms affects the structure of the resulting theory

- **Is the action principle well defined?** Add extra boundary terms and also specify the boundary conditions
- **How is the symplectic structure and conserved currents in the asymptotic region?** Finiteness after imposing the asymptotic fall off conditions of the fields or an event horizon
- How it changes the structure of the constraints?
- The covariant scheme well behaved $\rightarrow$ the canonical one?

# Generalized Holst action

The covariant Holst action with a boundary term

$$S_{GHA}[e,\omega] = -\frac{1}{2\kappa}\int_{\mathcal{M}} \Sigma^{IJ} \wedge \left(F_{IJ} + \frac{1}{\gamma} \star F_{IJ}\right) + \frac{1}{2\kappa}\int_{\partial\mathcal{M}} \Sigma^{IJ} \wedge \left(\omega_{IJ} + \frac{1}{\gamma} \star \omega_{IJ}\right), \tag{1}$$

whith $\Sigma^{IJ} = \star(e^I \wedge e^J) = \frac{1}{2}\varepsilon^{IJ}{}_{KL}(e^K \wedge e^L)$.
Taking the variation of the Holst action alone

$$\begin{aligned}
\delta S_{HA}[e,\omega] &= -\frac{1}{2\kappa}\int_{\mathcal{M}} [(Equation\, of\, motion)\delta e + (Equation\, of\, motion)\delta\omega] && (2)\\
&+ \frac{1}{2\kappa}\int_{\partial\mathcal{M}} \left[\Sigma^{IJ} \wedge (\delta\omega_{IJ} + \frac{1}{\gamma} \star \delta\omega_{IJ})\right] && (3)\\
& && (4)
\end{aligned}$$

# Covariant analysis of the Holst action plus topological terms

We want to study in the covariant scheme, the Holst action plus topological terms: Pontryagin, Euler, Nieh-Yan; and its behaviour under boundary conditions: Asymptotically flat and AdS spacetimes, and an inner boundary (Isolated Horizons).

$$S_T = S_{Holst\ action} + S_{Pontryagin} + S_{Euler} + S_{Nieh-Yan} \tag{5}$$

- Is the varitational principle well defined? Do we need to add additional boundary term? What are the boundary conditions to make it well defined?

  Asymptotically Flat: Yes, the variational principle is well defined if we add the same boundary term introduced to make well defined Holst Action. We need to prove finiteness of the whole action.

  Isolated Horizons: The variational principle is well defined for Holst action plus Euler and Pontryagin terms. Nieh-Yan is on progress. Also we need to check finiteness

  AdS: We are exploring the necessary boundary conditions.

- Which is the symplectic form and the conserved currents in the asymptotic region?
  *We prove a very interesting result, when we add topological terms to the actions, they does not contribute to the symplectic structure*

# Dirac analysis of the Holst action plus a boundary term

In the covariant scheme the action is well defined so we want to check if the canonical one is also well defined without time gauge.
Connect with the results obtained by Juan D Reyes and Alejandro Corichi, for time gauge fixing.

Thank you