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From generalized principal connections to generalized Yang-Mills theories

In the framework of the fiber bundle approach to covariant Lagrangian field theories we investigate the notions of generalized principal bundle and generalized principal connection as introduced by Castrillón López and Rodríguez Abella (2023), aiming at the development of an instance of generalized mathematical gauge theories. We provide a characterization of Lie group fiber bundle connections and generalized principal connections in order to obtain the local coordinate representation of all such structures. In particular, studying the curvature of generalized principal connections, we specialize the Bianchi identities obtaining a generalized version of the classical homogeneous field equations. As an application, we prove also that vector bundles are an example of generalized principal bundles, that a generalized principal connection on a vector bundle is an affine connection and that the generalized homogeneous field equations can be rephrased, in this case, in terms of basic soldering forms and torsion tensors. Finally, resorting to gauge theories and variational calculus on fiber bundles, we propose a first approach to (an instance of) generalized Yang-Mills theories. We accordingly prove that the corresponding variational field equations (i.e. Euler-Lagrange equations) generalize the classical Yang-Mills equations. While generalized Yang-Mills theories need more developments to give a full answer, we expect that the Einstein equations can be formulated ultimately as an example of generalized Yang-Mills equations. This is a joint work with Lorenzo Fatibene.

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