The Einstein Constraint Equations

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Mathematical general relativity (GR) has become a thrilling area of research within differential geometry and geometric analysis which has gained plenty of attention in recent times. In particular, the Einstein constraint equations (ECE) play a fundamental role in the initial value formulation of GR and the understanding of global properties of solutions. In this course, we intend to present to a broad audience both classical and recent results concerning the analysis of the ECE. Most notably, the geometric partial differential equation (PDE) techniques related to their conformal formulation, which make contact with classical problems in geometric analysis, such as prescribed scalar curvature problems. We will review classifications for constant mean curvature initial data on closed and asymptotically Euclidean manifolds as well as introduce recent techniques that allow us to work with far-from-CMC initial data. Finally, we will also introduce initial data gluing constructions associated to the ECE.

Prerequisites: Background in Differential Geometry and Riemannian Geometry are required. Some previous PDE experience, mainly related to elliptic PDEs, is encouraged. Part of these preliminaries will be reviewed in the written version, but, because of time constraints, they will be assumed during the lectures.