Initial data engineering

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General Relativity is fundamentally a dynamical theory and as such, the study of the Cauchy problem plays a central role. From a PDE perspective the Cauchy problem can be understood in two parts: the constraint equations (which are essentially elliptic) and the evolution equations (which are essentially hyperbolic). We present a new gluing construction for the Einstein constraint equations. This result is optimal in two ways. First it applies to *generic* initial data sets, in a sense that will be made precise. Secondly the construction is completely *local* in that the initial data is left unaltered on the complement of arbitrarily small neighborhoods of the points about which the gluing takes place. This has an obvious appeal for the applications to physics and is a feature which is quite different from other gluing constructions in geometric PDE. Using this construction we establish the existence of cosmological, maximal globally hyperbolic, vacuum space-times with no constant mean curvature (CMC) spacelike Cauchy surfaces. This result is interesting, since the traditional view of both mathematical and numerical relativists has been that the most useful and reliable choice of time for a globally hyperbolic space-time is one based on a foliation by CMC slices.

This is joint work with Piotr Chruściel and Jim Isenberg.