Structure-preserving numerical methods in relativity

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In many applications of computational methods for differential equations major advances have been achieved through structure-preserving discretizations, that is, numerical methods designed to preserve key geometric, topological, and algebraic structures of the differential equations at the discrete level. For partial differential equations, one of the prime examples has been the finite element exterior calculus or FEEC, which has led to highly successful new numerical methods for solid mechanics, fluid flow, electomagnetism, and other applications. The Einstein equations, being fundamentally geometric, seem a natural application for such methods, and, indeed were an early motivation for the development of FEEC. However, the design of structure-preserving finite element methods for the Einstein equations has been elusive. In this talk we will discuss this challenge and recent work that bears on its solution.