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On foliations related to the center of mass in General Relativity

In many situations in Classical Mechanics, understanding the motion of the center of mass of a system is key to understanding the general trend of the motion of the system. It is thus desirable to also devise a notion of center of mass with similar properties in General Relativity, as well as the corresponding center of mass coordinates.

However, while the definition of the center of mass via the mass density is straightforward in Classical Mechanics, there is a priori no definitive corresponding notion in General Relativity. We will pursue a geometric approach to defining the center of mass, using foliations by hypersurfaces with specific geometric properties. I will first illustrate this approach in the (easier) classical Newtonian setting and then review previous work in the relativistic situation, most prominently a fundamental result by Huisken and Yau from 1996. After introducing the foliation approach, I will discuss explicit counter-examples (joint work with Nerz) and discuss the analytic, geometric, and physical issues they illustrate. I will then present a new approach (joint work with Cortier and Sakovich) that remedies these issues. Moreover, I will briefly explain the construction of center of mass coordinates which is joint work in progress with Metzger.