Embedded Boundary Methods for flow in complex geometries

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Cut cells methods have been developed in recent years for computing flow around bodies with complicated geometries. They are an alternative to body fitted or unstructured grids, which may be harder to generate and more complex in the bulk of the flow field. Cut cell methods "cut" the flow body out of a regular Cartesian grid. Most of the grid is regular. Special methods must be developed for the "cut cells", which are cells that intersect the boundary. Cut cells can have irregular shape and may be very small.

In this talk we describe our work on two aspects of Cartesian cut cell methods. We first present a new slope limiter designed for cut cells. Since the cut cell centroids are not coordinate aligned, and the cells are extremely irregular in size and shape, standard limiters do not easily apply. Most practitioners use a scalar limiter, where all components of a gradient are limited by the same scalar. We have developed a new limiter based on solving a tiny linear program (LP) for each cut cell, which separately limits the x-and y-slopes in a linearity preserving way. We present computational results in two space dimensions showing greatly improved accuracy.

We then describe our current project to solve the 'small cell problem' - which is that explicit finite volume methods are not stable on the arbitrarily small cut cells. We couple an explicit finite volume scheme to an implicit scheme on only the cut cells. We discuss the conservation and accuracy of different ways of handling the coupling. We show preliminary results in two and three dimensions solving the incompressible Euler equations.