Challenges in multigrid for mixed elliptic/hyperbolic problems in radiation transport

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The Boltzmann transport equation is a linear PDE which governs the transport of neutral particles (i.e., neutrons, photons) in radiation transport problems. The steady-state, monoenergetic version of this PDE has 3 spatial dimensions (which we discretise with the FEM on unstructured grids) and 2 angular dimensions (of which there are several common discretisations), which results in a very large linear system, which forces the use of matrix-free methods. Furthermore, given different physical materials, the PDE can behave in both an elliptic or hyperbolic fashion in a single domain.

This makes designing effective multigrid schemes challenging, as directional information in hyperbolic regions is encapsulated within angular variables. Traditional AMG approaches also perform poorly on this system. An approach based on coarsening algorithms from AMGe and simple interpolation will be presented that performs well in diffuse regions, but suffers from difficulties in strongly hyperbolic regions.