High-Order Micro-Macro Decomposition Schemes for Boltzmann-BGK

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Abstract. The kinetic Boltzmann equation with the Bhatnagar-Gross-Krook (BGK) collision operator allows for the simulation of gas dynamics over a wide range of Knudsen numbers with a simplified collision operator. Efficient numerical methods for Boltzmann-BGK should be asymptotic-preserving, which allows the numerical method to be stable at fixed mesh parameters for any value of the Knudsen number, including in the fluid (very small Knudsen numbers), slip flow (small Knudsen numbers), transition (moderate Knudsen numbers), and free molecular flow (large Knudsen numbers) regimes. In this work, we develop a novel micro-macro decomposition scheme for solving the Boltzmann-BGK and Boltzmann-ES-BGK systems. Kinetic flux vector splitting techniques are used to develop accurate fluxes and to enforce boundary conditions. High order is achieved using discontinuous Galerkin finite element methods. Several numerical examples are shown to demonstrate the effectiveness of the proposed numerical scheme.