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Spatially Adaptive Asymptotic Preserving schemes for Stiff Moment Models of Rarefied Gases

Wednesday, November 17, 2021 2:45 PM (30 minutes)

Moment models are successfully used to simulate rarefied gases. They are hyperbolic balance laws that can be stiff with several spectral gaps, especially if the relaxation time significantly varies throughout the spatial domain. We perform a detailed spectral analysis of the semi-discrete model that reveals the spectral gaps. Based on that, we show the inefficiency of standard time integration schemes expressed by a severe restriction of the CFL number. As asymptotic preserving scheme, we use projective integration, which is an explicit scheme that is tailored to stiff multi-scale problems with large spectral gaps between one slow and (one or many) fast eigenvalue clusters. We then develop the first spatially adaptive projective integration schemes to overcome the prohibitive time step constraints of standard time integration schemes. The new schemes use different, possibly asymptotic preserving time integration methods in different parts of the computational domain, determined by the spatially varying value of the relaxation time. We use our analytical results to derive accurate stability bounds for the involved parameters and show that the severe time step constraint can be overcome. The new adaptive schemes can obtain a large speedup with respect to standard schemes.

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