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Asymptotic preserving schemes for plasma fluid models

I am interested in asymptotic preserving numerical algorithms to solve plasma fluid models. I present the method in the particular case of the quasi-neutral limit for the two-fluid Euler–Poisson system. In plasmas, the space and time scales of local charge unbalances are measured by two parameters: the Debye length and the plasma period. I am interested in situations where both parameters can be very small compared with typical macroscopic length and time scales: this is the so-called quasi-neutral regime. When a standard explicit scheme is used to discretize the two-fluid Euler–Poisson system, these micro-scale phenomena must be resolved. Hence, the space and time steps must be smaller than the Debye length and electron plasma period otherwise a numerical instability is generated. Then, explicit discretizations suffer from severe numerical constraints which make the use of explicit methods almost impracticable.

I will present an implicit scheme which is asymptotically stable and consistent in the quasi-neutral limit: this scheme does not need to resolve the small scales of the Debye length and plasma period, and in the quasineutral limit, a discretization of the quasineutral Euler model is recovered. Such a property is referred to as "asymptotic preservation": the scheme preserves the asymptotic limit. Additionally, in spite of being implicit, for given time and space steps, the scheme has the same computational cost as the standard explicit strategy.

I will finish with the presentation of extensions of this work to different systems and different limits.

This work is a joint work with P. Crispel and P. Degond from the Mathematic Institute of Toulouse, France.