Asymptotic-Preserving scheme for a highly anisotropic, parabolic temperature equation

Claudia Negulescu
Université de Toulouse

Abstract

This talk deals with the numerical study of a nonlinear, strongly anisotropic heat equation, arising in the modelling/simulation of magnetically confined fusion plasmas. Magnetically confined plasmas are characterized by highly anisotropic properties induced by the strong magnetic field. The charged particles constituting the plasma move rapidly around the magnetic field lines, their transverse motion away from B is constrained by the Lorentz force, whereas their motion along B is relatively unrestricted. This results in an extremely large ratio of the parallel to the transverse thermal conductivities, as well as of other parameters characterizing the plasma evolution. This anisotropy is described by a small positive parameter epsilon, appearing in the mathematical equations.

The numerical resolution of this kind of problems is very challenging. The use of standard schemes leads to a linear system, which is ill-conditioned for epsilon much smaller than 1, in particular with a condition number of the order of 1/epsilon, leading thus rapidly to computationally too costly simulations. The aim of this talk will be to introduce an efficient numerical method, based on asymptotic-preserving techniques, permitting to solve the highly anisotropic diffusion problem accurately on a coarse Cartesian grid, which has not to be adapted to the field lines of B and whose mesh size is independent of the value of the small parameter epsilon.