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A multi-dimensional staggered scheme for the diffusive limit in the radiative transfer equation

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The radiative transfer equation is a kinetic PDE modelling the specific radiation intensity carried by a population of photons described by a statistical description, i.e. a transport equation on the fraction of photons travelling in a given direction. It is well known that as the Knudsen number (which is the ratio of the mean free path length to a representative physical length scale) goes to zero, the radiation intensity tends to a solution of a diffusion problem.

In this talk, we present a numerical scheme for the radiative transfer equation that has the asymptotic preserving property: when the Knudsen number is fixed, we prove that the numerical solution converges to a solution of the radiative transport equation for vanishing discretisation parameters. And for a fixed discretisation, the numerical solution converges to the solution of a stable and consistent numerical scheme for the limit diffusion equation. The numerical scheme considered is an extension to the multidimensional setting of the 1D scheme developed by Lemou and Mieussens in their 2008 SIAM paper. It is based on a micro-macro decomposition of the main unknown and on a staggered discretisation: the macroscopic variable is cell-centred while the microscopic variable is face-centred. We show that special consistency problems arise in the multidimensional setting due to the fact that composing a consistent discrete divergence with a (weakly) consistent discret gradient does not generally yield a consistent Laplacian operator, even on admissible grids.

This is a joint work with Mohamed Ghattassi and Nader Masmoudi.

Presenter: SALEH, Khaled (Université Claude Bernard, Lyon 1)