Analysis of Turbulence Models Based on Kinetic Theory and the Development of Asymptotic Preserving Numerical Methods

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P. Degond and M. Lemou (Journal of Mathematical Fluid Mechanics, 4, 257-284, 2002) developed a new turbulence model based on kinetic theory for simulating incompressible fluid flows. This interesting alternative to traditional Reynolds Averaged Navier-Stokes (RANS) turbulence models needs further analysis and testing. In this proposal, we plan first to analyse this turbulence model in detail, comparing with other traditional turbulence models like the $k-\varepsilon$ turbulence model and its variants, focusing on the dimensionality and structure of the equations, including production and dissipation of the turbulence kinetic energy and the connection to Kolmogrov's law. The second part of this proposal is to develop *Asymptotic-Preserving numerical methods* (which has been an active area of research in the recent past in the context of hyperbolic conservation or balance laws with stiff relaxation/source terms) for kinetic turbulence models in the fluid limit and then propose a numerical framework for testing them.

The objectives of the projects are:

- Detailed derivations of Degond & Lemou's turbulence model from Kinetic Theory
- Analysis of turbulence kinetic energy and dissipation terms – dimensional and structural analysis
- Comparison with traditional *k*-e turbulence model
- Review of recent literature on Aysmptotic-Preserving schemes for hyperbolic conservation/balance laws with relaxation for optimal choice
- Formulation of the asymptotic-preserving scheme for kinetic theory based turbulence model in the fluid limit
- Formulation of relevant numerical framework for testing the new turbulence model

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