Implementation and Verification of Collision Operators in the Gyrokinetic Turbulence Code GENE-X

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Gyrokinetic codes are among the main tools used to simulate turbulent transport in the core of fusion devices. To extend the application of these codes into the plasma edge and scrape-off layer, multiple challenges must be faced, one of which is the much lower temperature and higher collisionality. To allow for realistic gyrokinetic modeling of edge and scrape-off layer turbulence, it is crucial to include collisional effects into the simulations.

In this work, we present recent developments of a hierarchy of different collision operators in the grid-based, gyrokinetic turbulence code `GENE-X`. The collision operators have been selected to vary in fidelity, complexity and cost, allowing to choose between computational intensity and physical accuracy. We present simple relaxation models (Bhatnagar-Gross-Krook), simplified Fokker-Planck type models (Lenard-Bernstein/Dougherty) and the full Fokker-Planck collision operator in the Landau formulation. Further we provide a verification through the study of conservation and relaxation properties and discuss the differences in computational performance.

For the two Fokker-Planck type models, the implementation with a second-order finite-volume scheme is given. This allows for the exact conservation of particle density, momentum and energy up to machine precision. Further, we discuss the influence of the Landau formulation on the achievement of these conservation properties in the discretized versions.