Neoclassical effects on the turbulence in non-Boussinesq tokamak edge scenarios have been studied by first principles NLET (non-local electromagnetic turbulence code [1]) simulations.

It is well known that close to the edge of a tokamak, where GAMs are prevalent, the turbulent and diamagnetic fluctuations become so large that the Boussinesq and related approximations break down. Then in turbulence computer studies it is necessary to take into account the finite ratio of the turbulence and system scales [1]. The breakdown may be described by the local ratio of turbulence to background gradient scale lengths $\lambda^{-1} = L_\perp/L_\parallel \propto \rho^* = \rho_s/R$, whereby $\lambda \sim 5 - 10$ for typical edge scenarios.

The Boussinesq break-down affects however not only directly the turbulence but also the background equilibrium and laminar flows, such as the zonal flows and the geodesic acoustic modes (GAM) [2] excited by the turbulence.

With the NLET code, the higher order nonlinearities due to large deviations of the fluctuating quantities from the background equilibrium are taken into account, as well as the ensuing radial variation of the neoclassical flows. Particular attention has been paid to securing the correct energy and momentum balance. The framework of the simulations are the set of two-fluid equations based on the Braginskii equations – at present the full nonlinearities of the edge cannot be implemented in a gyrokinetic framework.

The simulation parameters encompass the ITG, ballooning and drift wave regimes. At the focus of the investigation are the modification of the equilibrium return flows (Pfirsch-Schlueter current and corresponding ion flows) by the turbulence and the particle flow balance at the transition between the ITG modes in the core-edge transition region and the edge ballooning region. Other points of interest are the experimentally observed discrete frequencies spectra of GAMs at the edge [3, 4, 5], and the evolution of the zonal flows [6].

References