# Monte Carlo Simulation of Neoclassical Edge Pedestal Formation and Study of Pedestal Scaling Law

C. S. Chang,[1,2] Sunghoe Ku,[2] H. Weitzner,[1]
[1]*Cournat Institute of Mathematical Sciences, New York University, New York, NY 10012, USA*
[2]*Korea Advanced Institute of Science and Technology, Daejon 305-710, Korea*

Abstract

Understanding and predicting the edge pedestal behavior in H-mode remains to be one of the most critical issues in ITER Physics. After the turbulence suppression, the plasma transport in the H-mode layer is likely to be neoclassical. However, the neoclassical physics for pedestal plasmas cannot be analyzed by a conventional theory due to steep gradient on the order of thermal ion banana width, ion loss cone near the X-point [1], and the neutral effects.

A massively parallel Monte Carlo guiding center ion code XGC (X-point included Guiding-center Code) is built to study self-consistently the neoclassical transport, orbit loss, and neutral effects in realistic flux surface and wall geometry. XGC is a time-dependent full f code, with conserving Monte Carlo Coulomb collision. A Monte Carlo neutral atom diffusion module is built in for a reliable neutral recycling and penetration dynamics. A continuous heat out flow from the core is modeled in to control the pedestal temperature.

Build-up to a maximal neoclassical pedestal (H-mode shape) from an L-mode shape by the neutral ionization is observed. It is found that the particle source from neutral ionization is balanced by the strong convective particle loss around the X-point to give a distinctive pedestal shape. A stronger neutral ionization raises the density pedestal height, and a stronger heat outflow from the core raises the temperature height. Figure 1 shows a maximal neoclassical edge density pedestal obtained from XGC in a 1 Tesla DIII-D plasma. Agreement with the Tanh-fit (line) is remarkably good. The pedestal width here is about 1 cm, which roughly agrees with the experiments. At higher magnetic field, the pedestal width decreases in proportion to 1/B. XGC shows a strong electric field well developed in the pedestal region.

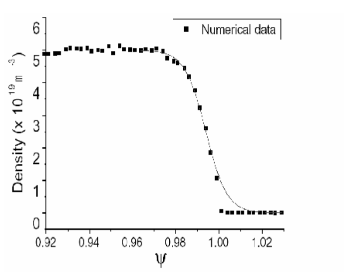


Fig. 1. Neoclassical edge density pedestal with a tanh-fit.

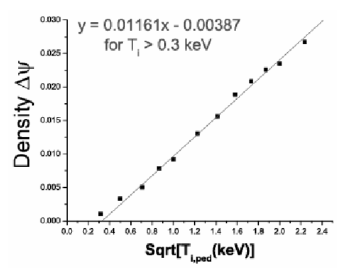


Fig. 2. Density pedestal width in ψ as function of square root of the ion pedestal temperature

Figure 2 shows scaling of the density pedestal width (in ψ) against the square root of the pedestal ion temperature. It shows an offset linear behavior above 300 eV. Similar scaling studies with magnetic field show rather surprising results. The pedestal width does not show a $1/B_\theta$ dependence. But, it rather shows a $1/B_T$ dependence. Thus, the density pedestal width does not scale as the poloidal ion gyroradius! Comparisons with experiments will be presented. Additionally, a positive toroidal momentum source is found at the edge.