Simulation of electrode biasing in the edge and scrape-off layer regions of a Tokamak

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Electrode biasing in the tokamak edge region is an important topic as it can control particle recycling, exhausts, confinement time, and reduction of heat loads on the limiter plates. In many Tokamaks [1,2] it has been seen that external biasing may be one of the causes of the transition of L-mode to H-mode. In this work, we have investigated numerically the effects of biasing using two-dimensional electron conservation, quasi-neutrality, and electron energy equations with the help of a drift interchange model [3,4,5] in the edge and scrape-off layer (SOL) regions of a tokamak plasma. The numerical simulation has been performed using the BOUT++ framework on the Antya HPC cluster. The edge and SOL regions have been coupled together. Typical I-V characteristics in the presence of finite electron temperature gradient have been obtained numerically and its characteristics have been compared with Aditya Langmuir probe data.

Using numerical data the effect of the poloidal and radial width of the biased probe in the edge region (limiter biasing [6]) has been investigated. It is found that the radial profile becomes more peaked for lower poloidal biasing length, but when the length increases more than 35 ion gyro-radius (ρ_s) then the radial profiles do not vary with the length of the probe. This is due to the fact that the radial electric field at 35 ion gyro-radius (ρ_s) gives the maximum radial electric field as shown in the Figure-1. This is a very important and new results of this work.

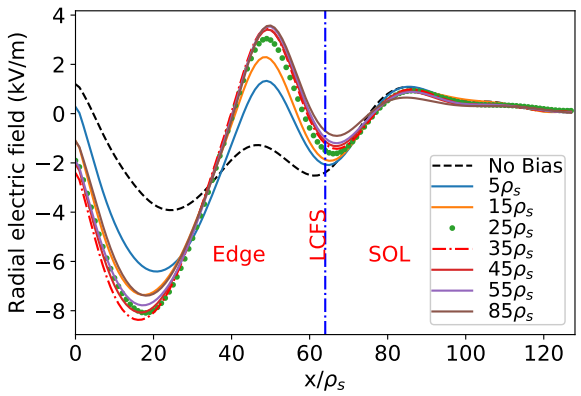

Figure-1: Radial electric field as a function of poloidal dimension

Turbulent decorrelation rate and radial electric field shear have been investigated and found that they are almost the same order of magnitude. We have investigated the effect of positive and negative biasing in the tokamak edge region. For both cases, an increase in edge plasma density, temperature, and steepening of its radial profile have been observed. The impact of probe biasing position from the last closed flux surfaces (LCFS) has been carried out. It is found that positive biasing is much effective inside the edge region while negative biasing does not affect by a change in bias position.

References:

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