STUDY OF REVERSED MAGNETIC SHEAR CONFIGURATION IN ADITYA-U TOKAMAK

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For the past several years, there has been a keen interest in designing a steady state fusion reactor which is stable to Magnetohydrodynamic (MHD) instabilities as well as microinstabilities. It is well known that, reversed shear q profiles exhibit good confinement properties and, relatively good MHD stability. This steered much research towards Advanced Tokamak (AT) regime [1,2,3], which are typically characterized by high poloidal beta, strong internal & edge pressure gradients and relatively broader current profiles, resulting in stable configuration compared to standard q profiles.

A relatively MHD stable tokamak is yet prone to the microinstabilities resulting in high anomalous transport. It is well-known fact that, Ion Temperature Gradient (ITG) modes[4,5] are responsible for high ion heat flux resulting in reduced confinement time. Past research reported that, in the presence of reversed shear q profiles, linear growth rates and ion heat flux are relatively lower in comparison to the standard q profiles. This is due to the increased **E**x**B** shearing rate, which is responsible for breaking the large turbulent eddies into smaller eddies, thereby reducing the spatial and temporal turbulence correlation times. Aditya-U tokamak [6,7] has been recently upgraded for auxiliary heating using ICRH and LHCD, which may be configured to perform off-axis heating & current drive, resulting in a plausible reversed shear q profile. Such a magnetic configuration has been relatively less explored for a small-to-medium aspect ratio tokamak like ADITYA-U.

In the present work, starting from an exact circular MHD equilibria as shown in Fig 1. generated using Grad-Shafranov solver CHEASE [8], for global parameters closely resembling the ADITYA-U Tokamak [9,10], we study the effect of reversed shear q profile on microinstabilities and transport driven by ITGs. Fig 2. shows the temperature, density and q profiles of ADITYA-U used to generate the equilibria and perform the simulations. A gyrokinetic simulation was performed using the global electromagnetic gyrokinetics PIC code ORB5[11]. In these simulations, Hydrogen ions are treated as gyrokinetic and electrons as adiabatic species, with 900M particles each. The toroidal mode numbers range from $0 \leq n \leq 100$, and field aligned filter is used such that, poloidal mode numbers are retained from $m \in [m_{min}, m_{max}] \cap [-nq_s-\Delta m, -nq_s+\Delta m]$, resolving upto $k_\theta \rho_i \sim 1.50$. The time Δt and phase-space grid resolution are chosen in such way that it resolves all the relevant modes required to study the ITGs. A Krook type noise control is used in order to improve the signal-to-noise ratio for the simulation. Fig 3. shows the spatio-temporal plot of the ion heat flux in the presence of reversed shear q profiles. Fig 4. shows the radial derivative of electrostatic potential, one can clearly see that Geodesic Acoustic Modes (GAMs) for s > 0.8 (vertical steaks in the figure). Along with the MHD circular equilibria, this study will also include the effects of equilibrium shaping in the presence of reversed q profiles and its comparison with the former, for ADITYA-U parameters.

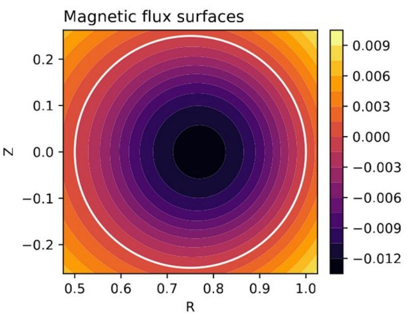

Figure 1: Magnetic flux surfaces generated using CHEASE [8].

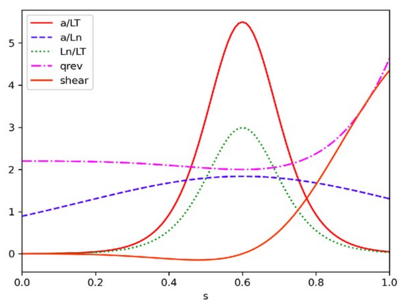

Figure 2: Equilibrium profiles used for generation of flux surfaces and perform simulations.

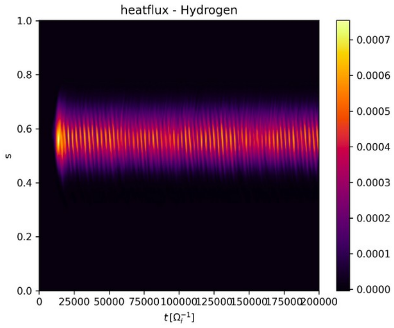

Figure 3: Spatio-temporal plot of ion heat flux for ADITYA-U tokamak.

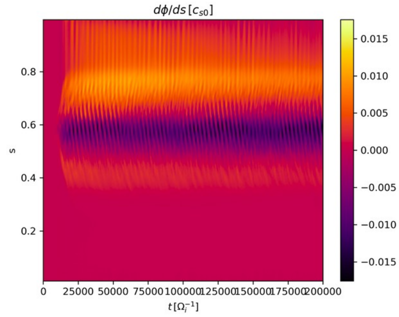

Figure 4: Spatio-temporal plot of radial derivative of electrostatic potential for ADITYA-U tokamak.

ACKNOWLEDGEMENTS

All simulations were performed on ANTYA HPC, which is a 1 Peta FLOPs cluster located at the Institute for Plasma Research (IPR). All the simulations were performed using nonlinear global gyrokinetic PIC code ORB5[11], in collaboration with EPFL, SPC, Switzerland.

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