Simulation of NBI ion losses using GPUs.

H. E. Ferrari[1,2],R. Farengo[1,3], P. L. Garcia-Martinez[2], C. F. Clauser[4]

[1]*CNEA, CAB, Bariloche, Argentina*

[2]*CONICET, Argentina*
[3] *IB, UnCuyo, Bariloche, Argentina.*
[4] *Lehigh University, Bethlehem PA 18015, United States*

Energetic ion losses due to neoclassical tearing modes (NTM) have been reported in ASDEX-U [1]. To study this problem we have used FOCUS, a full orbit code that runs in Graphical Processing Units (GPU) [2]. Using GPUs allows us to run a large number of ions with modest resources. The perturbed fields were calculated employing the experimental information available and the method proposed in [3].

In a previous work [4] we reported an increase in ion losses when the frequency of the NTM matches the precession frequency of the trapped particles ($f \sim \sqrt{E}$) . In the ASDEX U experiment the frequency of the NTMs was 6 kHz and the precession frequency of the injected ions (at 93 KeV) was f_p ~ 8kHz. For the ions with E0 = 93keV the losses increased by a factor 2, from 2% in the static case to 4% in the rotating case.

Since a fraction of the injected neutral atoms (~ 1/3) have an energy equal to half the maximum value (46.3 keV**s**) it is also important to study NTM induced losses at this energy. The 46.3 keV ions have an average precession frequency similar to the measured NTM frequency and the strong resonance results in a 23% loss of the trapped ions. These results show the importance of including the full time dependency of the perturbation.

[1] M. García-Muñoz et. al. *Nucl. Fus.* **47**, L10 (2007).
[2] C. F. Clauser et al. *Comput. Phys. Comm.* **234**, 126 (2019).
[3] V. Igochine et al, *Nucl. Fus.* **43** 1801 (2003).
[4] H. E. Ferrari et al., APS-DPP 2020 Virtual Meeting, 9-13 November 2020. "*Energetic ion losses driven by resonant NTMs*".