The ionization peak location in the determination of neutral opaqueness in DIII-D plasmas

J. Balbin-Arias[1], S. Mordijck[1], T. Wilks[2] , L. Horvath[3], T. Odstrcil[4], R.Chaban[1],A. M. Rosenthal[2], J. W. Hughes[2], A. Bortolon[3], F. M. Laggner[5]

[1]William & Mary, Williamsburg, USA

[2]MIT Plasma Science and Fusion Center, Massachusetts, USA

[3]Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543, USA

[4]General Atomics, San Diego, CA 92186-5608, United States of America

[5]Department of Nuclear Engineering, North Carolina State University, Raleigh, NC 27607, USA

Contact: jjbalbinarias@wm.edu

We present a database study highlighting the role of fueling by neutrals, where the neutral penetration and opaqueness on the H-mode pedestal are analyzed. A screening effect on neutrals by increasing pedestal density has been observed from a database of neutrals inferred using LLAMA diagnostic measurements. The expected proportional relationship between the two approximations for the opaqueness of neutrals [1,2] breaks down for low pedestal densities and high electron temperatures in the separatrix.

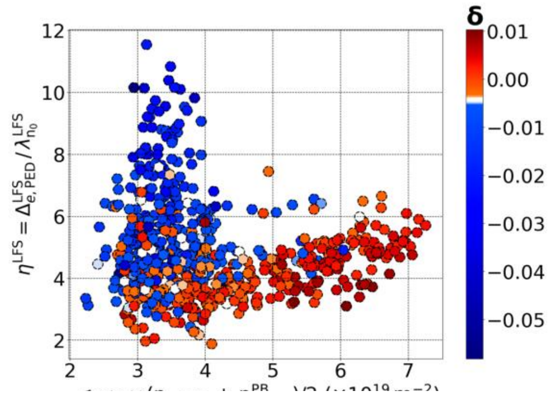

Figure (1) Comparison between the experimental opaqueness (vertical axis) and the heuristic approximation (horizontal axis). When the ionization peak is in the scrape-off layer the relationship between the opacities is linear (red color), while when the ionization peak is in the pedestal region (blue color) then the relationship diverges from linear.

The database includes lower single null ELMy plasmas with favorable ion diamagnetic drift. The database includes stationary conditions of the order of the energy confinement time ~ 100 - 200ms [3], and data is restricted to 80-99% of the ELM cycle [4]. The separatrix location is determined using the power balance method [5]. The neutral density profile is measured using the LLAMA diagnostic [6] and fitted with an exponential on both the HFS and LFS $n_0(r) = n_{0,SEP} \times EXP\{(r - r_{SEP})/\lambda_{n_0}\}$ [4,7], where λ_{n_0} is the penetration depth of the neutrals. The electron density and temperature are measured using the Thomson Scattering (TS) and fitted with a $tanh$ [8] at each time. Using the pedestal electron density width $\Delta_{e,PED}$, we can calculate the opaqueness, $\Delta_{e,PED}/\lambda_{n_0}$, and compare this to the heuristic approximation for opaqueness $n \times a$, where a is minor radius and n is the average of $n_{e,SEP}$ and $n_{e,PED}$, as shown in Figure 1 [1]. We hypothesize that the breakdown of the proportionality between opaqueness approximations could arise by the effect of enhanced neutral penetration from charge-exchange neutrals.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences, using the DIII-D National Fusion Facility, a DOE Office of Science user facility, under Awards DE-FC02-04ER54698, DE-SC0019302, DE-SC0014264 and DE-AC02-09CH11466.

[1] S. Mordijck et al, Nucl. Fusion 60 (2020) 082006.

[2] R.A. Chaban et al, APS-DPP 2023.

[3] C. Paz-Soldan et al, Plasma Phys. Control. Fusion 63 083001 (2021).

[4] R.A. Chaban et al, Nucl. Fusion 2024 (Accepted Manuscript).

[5] J. Balbin-Arias et al, Contributions to Plasma Physics, 60 (2020), 5-6.

[6] A.M. Rosenthal et al, Nucl. Fusion 63(2023) 042002.

[7] R. Reksoatmodjo et al, Nuclear Materials and Energy 27 (2021) 100971.

[8] R. J. Groebner et al, Fusion Science and Technology, 48:2, 1011-1020.