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Initial exploration of the density limit in the MST RFP

M. D. Wyman[1], B. E. Chapman[1], D. L. Brower[2], S. K. Combs[3], B. H. Deng[2], W. X. Ding[2], D. T. Fehling[3], C. R. Foust[3], S. P. Oliva[1], S. C. Prager[1]

[1] *University of Wisconsin-Madison, Madison, Wisconsin USA*

[2] *University of California-Los Angeles, Los Angeles, California USA*

[3] *Oak Ridge National Laboratory, Oak Ridge, Tennessee USA*

The density limit and its underlying physics in modern, larger-scale RFP plasmas has only begun to be explored. Establishing the density limit is important in part since there are as yet few known fundamental operational limits in the RFP. In tokamak plasmas without pellet injection, the central line-averaged electron density, $\langle n_e \rangle$, is generally limited to the Greenwald value, $n_G = I_p/\pi a^2$. This limit applies as well to plasmas in the RFX RFP, and we observe it to play at least some role in MST plasmas. This tokamak-RFP commonality suggests that perhaps additional light can be shed on the physics of the density limit by measurements made in the RFP.

We report here initial measurements made in the MST, which produces toroidal deuterium RFP plasmas with major and minor radii of 1.5 m and 0.51 m, respectively. By injecting deuterium pellets into standard, low-confinement plasmas, one is easily able to exceed n_G, but not without consequences. As $\langle n_e \rangle$ exceeds n_G, the toroidal plasma current begins to ramp down. If $\langle n_e \rangle$ is sustained above n_G for a sufficiently long time, the discharge terminates. If $\langle n_e \rangle$ drops back below n_G, the plasma current can recover. This decay of the current with pellet injection is in contrast to what has been achieved in at least some tokamak plasmas, where little or no decay of the current is observed. The difference may be linked to the relatively rapid global particle transport time scale (1 ms) in MST standard plasmas which allows the quick transfer of core-deposited particles to the edge.

Without pellet injection, some low current (I_p < 200 kA) MST plasmas are observed with $\langle n_e \rangle$ apparently exceeding n_G for the duration of the discharge. These discharges exhibit a flattop in the plasma current, as usual, but the discharge length is substantially shorter than usual. During the first and last few milliseconds of more normal discharges, when the current is ramping up and ramping down, respectively, $\langle n_e \rangle$ routinely exceeds n_G. We are working to understand this phenomenology.

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