Initial exploration of the density limit in the MST RFP

M. D. Wyman¹, B. E. Chapman¹, D. L. Brower², S. K. Combs³, B. H. Deng², W. X. Ding², D. T. Fehling³, C. R. Foust³, S. P. Oliva¹, S. C. Prager¹

¹University of Wisconsin-Madison, Madison, Wisconsin USA
²University of California-Los Angeles, Los Angeles, California USA
³Oak 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, \( <n_e> \), 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 \( <n_e> \) exceeds \( n_G \), the toroidal plasma current begins to ramp down. If \( <n_e> \) is sustained above \( n_G \) for a sufficiently long time, the discharge terminates. If \( <n_e> \) 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 \( (I_p < 200 \text{ kA}) \) MST plasmas are observed with \( <n_e> \) 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, \( <n_e> \) routinely exceeds \( n_G \). We are working to understand this phenomenology.

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