Dependence of the LH power threshold on the X-point radius in NSTX

D.J. Battaglia[1], C.-S. Chang[2], S.M. Kaye[2], S. Ku[2,3], R. Maingi[1]

1 Oak Ridge National Laboratory
2 Princeton Plasma Physics Laboratory
3 New York University

The L-H power threshold (P_{LH}) is found to increase 40 – 80% on NSTX when the X-point radius is moved inward from R_X = 0.64m to 0.47m. This is consistent with neoclassical XGC0 calculations that indicate the edge radial electric field (E_r) well depth (thus, E_r *x B* shear) decreases with smaller R_X for matched plasma conditions. The XGC0 code includes the effects of X-transport, which is a non-ambipolar loss of collisionless ions through the X-point in the absence of electric fields and flows. The E_r is calculated self-consistently with XGC0, and must be large enough to cancel this ion loss mechanism. The constraint on the minimum $|E_r|$ from X-transport is predicted to be significant in the spherical tokamak since the low-aspect-ratio geometry enhances the number of trapped ions capable of X-transport. Single-particle guiding-center calculations indicate the smaller R_X reduces the number of trapped ions that pass through the X-point and leads to an increase in the critical T_i for orbit loss from a particular flux surface. Consequently, the edge T_i must be on the order of 60% larger for the smaller R_X case than the larger R_X case in order to match the X-transport rate. This result provides intuition into the XGC0 results and supports the experimental observations. The dependence of P_{LH} on R_X is found to hold over a large range of edge collisionality, which is modified on NSTX using lithium coatings in the divertor. The impact of the X-transport dynamics are found to be qualitatively consistent with other P_{LH} trends on NSTX, including the dependence on plasma current, X-point balance, grad-B drift direction and toroidal loop voltage.