Optimization of the safety factor profile for high noninductive current fraction discharges in DIII-D*

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Abstract. In order to assess the optimum q profile for discharges in DIII-D with 100% of the current driven noninductively (f_{NI} = 1), the self-consistent response of the plasma profiles to changes in the q profile was studied in high f_{NI}, high β_N discharges through a scan of q_{min} and q_{95} at two values of β_N. As expected, both the bootstrap current fraction, f_{BS}, and f_{NI} increased with q_{95}. The temperature and density profiles were found to broaden as either q_{min} or β_N is increased. A consequence is that f_{BS} does not continue to increase at the highest values of q_{min}. A scaling function that depends on q_{min}, q_{95}, and the peaking factor for the thermal pressure was found to represent well the f_{BS}/β_N inferred from the experimental profiles. The changes in the shapes of the density and temperature profiles as β_N is increased modify the bootstrap current density (J_{BS}) profile from peaked close to the axis to relatively flat in the region between the axis and the H-mode pedestal. Therefore, significant externaly-driven current density in the region inside the H-mode pedestal is required in addition to J_{BS} in order to match the profiles of the noninductive current density (J_{NI}) to the desired total current density (J). In this experiment, the additional current density was provided mostly by neutral beam current drive with the neutral-beam-driven current fraction 40%-90% of f_{BS}. The profiles of J_{NI} and J were most similar at $q_{min} \approx$ 1.35-1.65, $q_{95} \approx$ 6.8, where f_{BS} is also maximum, establishing this q profile as the optimal choice for f_{NI} = 1 operation in DIII-D with the existing set of external current drive sources.

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