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High β_p Equilibrium and Bootstrap Current Overdrive in Low Aspect Ratio Tokamaks

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Due to space limitations at the central column of low aspect ratio tokamaks (LAT), transformerless operation of the LAT tokamaks will be highly desirable. Also the large magnetic well in LATs gives rise to a large trapped particle fraction which renders conventional non-inductive current drive schemes inefficient. In this work we examine the use of bootstrap current overdrive to ramp the plasma current in an LAT (aspect ratio of 1.4 and elongation of 3) configuration. By selecting a target plasma with sufficiently low current and high enough β_p, the neoclassical bootstrap current could exceed the total plasma current and provide the emf for ramping the current. The current ramping rate is determined by the amount of excess bootstrap current and $\tau_{L/R}$, the skin time. With density control, a high ramping rate might be obtained with sufficiently low collisionality. Using the TOQ equilibrium code, we have constructed stable high β_p ($\varepsilon\beta_p > 3$) equilibria for the target plasma with I_p = 200–300 kA. Taking the density to be 0.5–0.8 of the Greenwald limit, the target plasma is shown to have a bootstrap current fraction greater than 150% and a skin time on the order of 1 s. Using a 0-D simulation, the current is shown to ramp to 1 MA with a rate of about 0.5 MA/s. Discussions on the appropriate skin time to be used in LAT and justification of the 0-D simulations using 1-D transport calculations will be presented.

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