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Self Organization of High Beta_p Plasma Equilibrium with an Inboard Poloidal Null Sustained by Fully Non-Inductive Current Drive in QUEST

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There is a considerable interest in operating tokamak at high value of beta_p , but maximum attainable beta_p is limited by a equilibrium limit with appearance of a null point at the inboard side. Such configuration is realized transiently earlier by Electron Cyclotron Waves, but in QUEST such equilibrium is stably produced in steady state and its equilibrium properties are investigated. In QUEST, successful production of high beta_p plasma (beta_p > 1) and its long pulse sustainment by fully non-inductive (NI) current drive with the help of a modest power (< 100 kW) ECW is demonstrated. High beta_p plasma is formed by confining energetic electrons produced by multiple resonant EC interaction in a high magnetic mirror configuration and high Bz/Bt > 0.1. We found that (i) high beta_p plasma is naturally self organized to form a stable natural Inboard Poloidal field Null (IPN) equilibrium, (ii) a critical beta_p, which defines the transition boundary from Inboard Limiter (IL) to IPN equilibrium and (iii) a new feature of plasma self organization to enhance its negative triangular shape to sustain high beta_p. With high beta_p formation, plasma naturally self organizes itself to reduce the elongation as first observed in TFTR, which is also observed in the present case. However, we found a new self organization feature, where plasma shape adjusts itself to becomes more negatively triangular. This new feature overcompensates the diminution of beta_p due to the reduction in elongation. A simple analytic solution of Grad-Shafranov equation is applied to investigate such aspect. The model supports this facet which, predicts higher beta_p at larger negative triangularity. The boundary flux surfaces generated through the model agree well with the measurements. The model is also in agreement with the critical beta_p for IL to IPN transition, which is very well matched with the measurements. This result shows a relatively simple method to produce and sustain high beta_p plasma close to the equilibrium limit in a stable configuration exploiting its self organization property.

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