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TH/P4-13: Edge Electric Fields in the Pfirsch-Schlüter Regime and their Effect on the L-H Transition Power Threshold

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In the collisional tokamak edge plasmas just inside the separatrix, a radial electric field can be associated with the Pfirsch-Schl\"uter currents, and poloidal density and temperature gradients. Building upon our previous works, this mechanism is further clarified and quantified here. Dependence of the resulting electric fields on magnetic topology, geometric factors like the upper/lower triangularity and elongation, and the relative position of the X-point(s) in the poloidal plane are examined in detail. Starting with the assumption that an initially more negative radial electric field at the edge helps lower the transition power threshold, we find that our results are in agreement with a variety of experimental observations. In particular, for a normal" configuration of the plasma current and toroidal field we show: (i) The net radial electric field contribution by the Pfirsch-Schlüter currents at the plasma edge is negative for a lower single null (LSN) and positive for a corresponding upper single null (USN) geometry. (ii) It becomes more negative as the X-point height is reduced. (iii) It also becomes more negative as the X-point radius is increased. These observations are consistent with the observed changes in the L-H transition power threshold under similar changes in the experimental conditions. In addition we find that: (iv) In USN with an unfavorable ion grad-B drift direction, the net radial electric field contribution is positive but decreases as the X-point radius decreases. This is consistent with the C-Mod observation that an L-I Mode transition can be triggered by increasing the upper triangularity in this configuration. (v) Locally the radial electric field is positive above the outer mid-plane and reverses sign with reversal of the toroidal field, consistent with DIII-D observations in low-power L-mode discharges. Thus, taken as a whole, the Pfirsch-Schl\"uter current-driven fields can explain a number of observations on the L-H or L-I transition and the required power threshold levels not captured by simple scaling laws. They may indeed be an importanthidden variable."

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