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TH/P3-30: On the Origin of Tokamak Density Limit Scalings

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The onset criterion for radiation driven islands [1] in combination with a simple cylindrical model of tokamak current channel behavior is consistent with the empirical scaling of the tokamak density limit [2]. A number of the unexplained phenomena at the density limit are consistent with this novel physics mechanism. Issues addressed in this work include:

1) The scaling is universal, but the density limit appears associated with radiative collapse which can be complicated given the quantum nature of impurity line radiation.
2) If the physics is associated with radiative collapse, why is the density limit so weakly dependent on heating power?
3) Why is the limit only weakly dependent on the type of radiator?
4) The collapse is associated with the onset of magnetic islands, so why does the limit not depend on plasma shaping which is known to affect MHD stability)?
5) Why is the density limit power scaling different in stellarators?
6) Why are tearing modes associated with the radiative collapse?

It is hoped that given the apparent success of this simple model in explaining the observed global scalings will lead to a more comprehensive analysis of the possibility that radiation driven islands are the physics mechanism responsible for the density limit. In particular, with modern diagnostic capabilities detailed measurements of current densities, electron densities and impurity concentrations at rational surfaces should be possible, enabling verification of the mechanism described above.

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