Are radiation driven islands the cause of the density limit?

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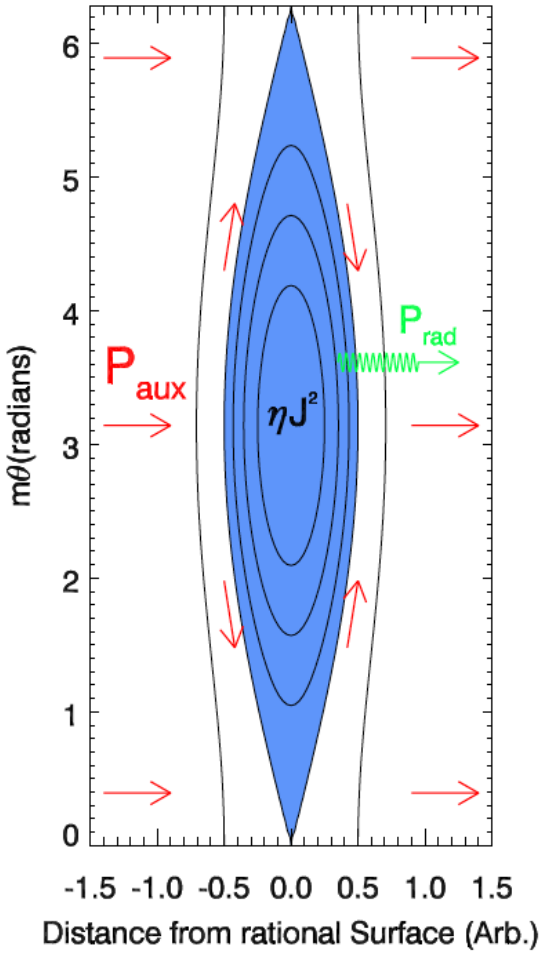
Radiation driven islands

- Inside an island impurities accumulate
- This cools the island,
- The lower temperature leads to increased resistivity
- This enhances the helical current perturbation
- the island grows causing the process to continue.



P. H. Rebut and M. Hugon, Plasma Physics and Controlled Nuclear Fusion Research 1984 (Proc. 10th Int. Conf. London, 1984), Vol. 2, IAEA, Vienna, 197, (1985).

These islands have been identified at the density limit

- Suttrop et al. did extensive study on ASDEX-U (1997)
- Did not draw a causal connection between islands and the density limit
- Did identify at least some of the islands as radiative

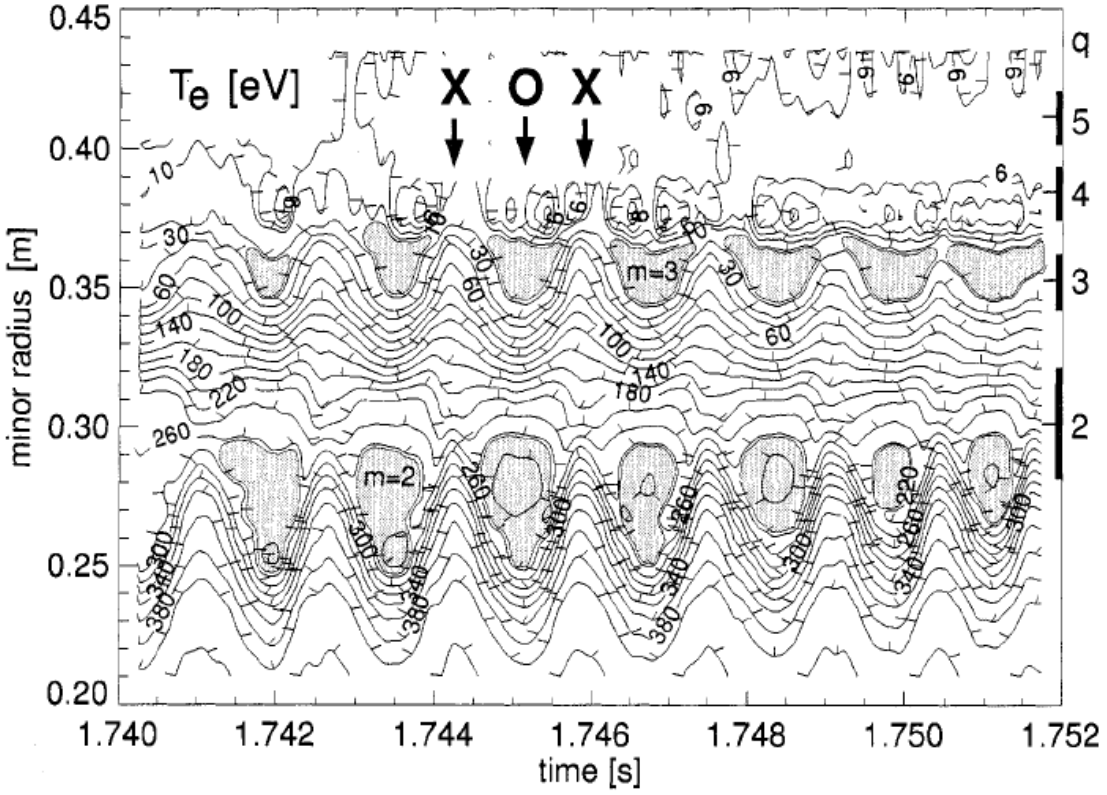


FIG. 2. Reconstruction of coupled (2,1) and (3,1) islands from T_e measurements in a time interval during current profile contraction between two minor disruptions. Islands recognized by regions of flat T_e are marked by shaded areas. While the (3,1) island grows, the (2,1) island shrinks. $q(r)$ is derived from equilibrium reconstruction at $t = 1.75$ s with radial uncertainties indicated.

Onset condition determined by power balance

$$P_{rad} < \eta J^2 \quad or \quad n_e E_{ave} \upsilon_{eZ} < \frac{m_e \upsilon_{ei}}{e^2 n_e} J^2$$

$$n_e < \sqrt{\frac{m_e}{e^2 E_{eff}} \frac{\upsilon_{ei}}{\upsilon_{eZ}}} J$$

- Auxiliary power is shunted around the island by parallel conduction, explaining why the density limit does not depend on heating power
- Quantity in square root is nearly independent of temperature*

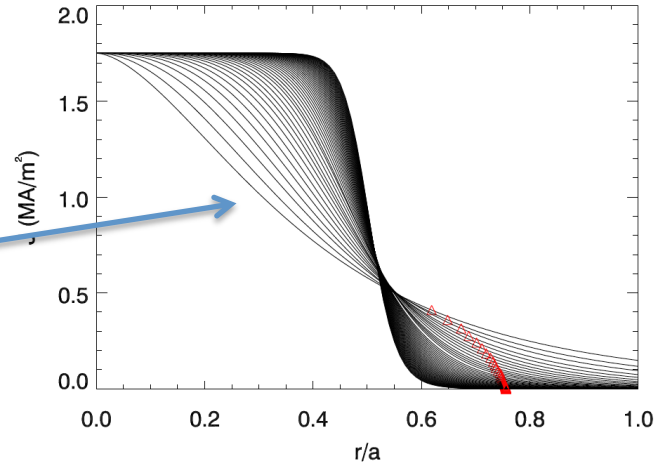
*F. W. Perkins and R. A. Hulse, Phys. Fluids **28** (1985) 1837.

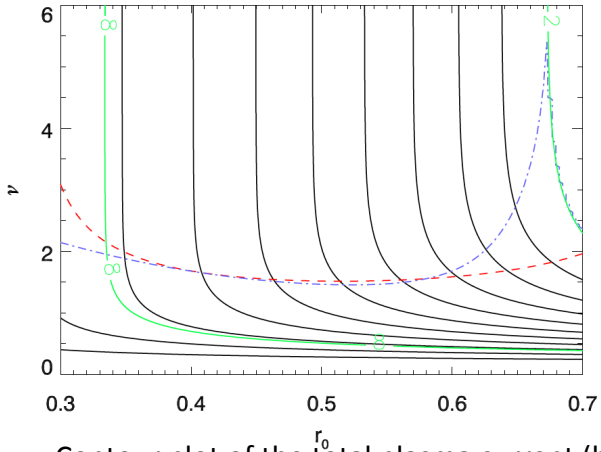
Simple cylindrical model relates local density and current to global values

- Use a simple profile model

$$J = \frac{J_0}{\left(1 + \left(\frac{r}{r_0}\right)^{2\nu}\right)^{1+\frac{1}{\nu}}}$$

- Add information on the dependence of l_i on q_{95}* at the density limit and parabolic density profile





Contour plot of the total plasma current (black) as a function of the profile parameters ν and r0. Also shown in the plot are the contour of the current profile peaking at the density limit and the best fit contour of the radiation driven island criterion

*J. A. Wesson, R. D. Gill, M. Hugon, F. C. Schuller, J. A. Snipes, et al., Nucl. Fusion **29** (1989) 641