SOME COMMENTS ON BARRIER DYNAMICS

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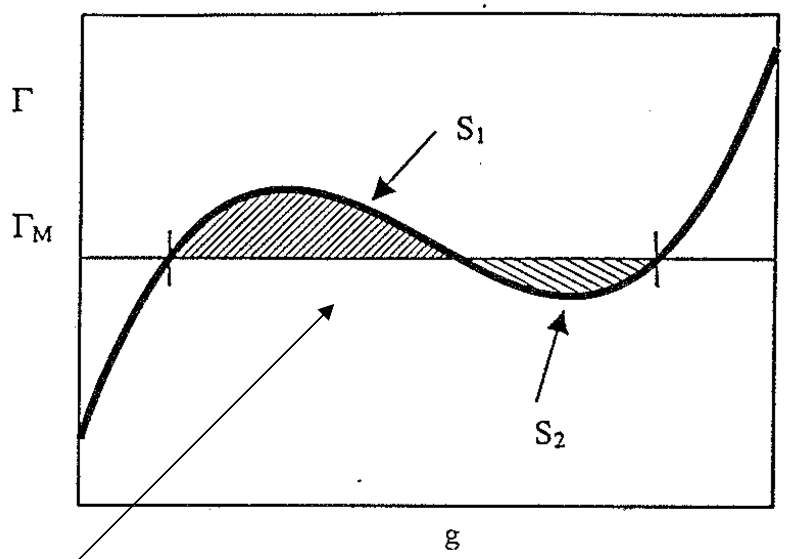
TRANSPORT BIFURCATION

- Construct profiles from segments of L and H mode solutions

- Barrier width determined by 'higher order' flux

$$\Gamma_1 \sim \varepsilon(d^3 n / dx^3) \Rightarrow \quad \Delta_b \sim \varepsilon^{1/2} L$$



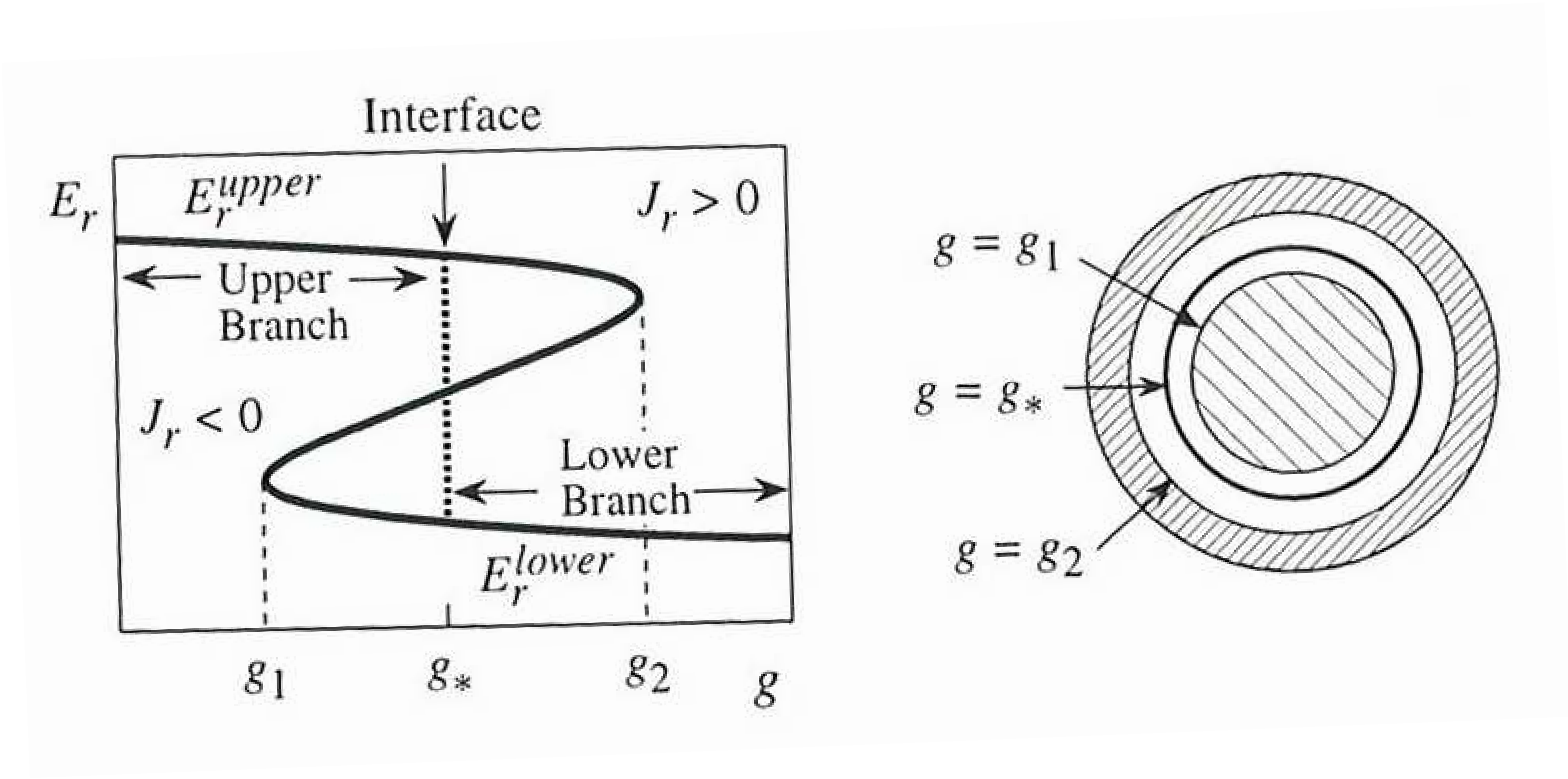
- Stationary position of barrier given by Maxwell construction: $\Gamma(x_b) = \Gamma_M$

- Out of equilibrium, barrier propagates:

$$x_b(t) = \left(\frac{(\Gamma - \Gamma_M)}{2\Gamma} D_H t \right)^{1/2}$$

V B Lebedev & P H Diamond, Phys Plasmas **4** 1087 (1997)

ELECTRIC FIELD BIFURCATION



Control parameter g(r) varies with plasma radius, r

K Itoh et al Transport & Structural Formation in Plasmas 1999 IoP p 258

BARRIER POSITION

- Poloidal force balance

$$\frac{\varepsilon_0 \varepsilon_\perp}{e}\frac{\partial E_r}{\partial t} = J_r^{Local} - \nabla_\perp \mu_{eff} \nabla_\perp E_r; \quad \mu_{eff} = M_{eff}\frac{m_i n_i}{B^2}\mu_i << 1$$

Depends on ion collisionality

- Consider functional

$$F(E_r, g) = \int_{E_r^{Lower}}^{E_r} dE_r J_r^{Local}(E_r, g)$$

- Integrating

$$\frac{1}{2}\mu_{eff}\left|\nabla E_r(r)\right|^2 - F(E_r) = \text{ Constant } = 0 \quad \text{(at Lower side)}$$

$$\Rightarrow F(E_r^{Upper}, g) = 0 \quad \text{(at Upper side)}$$

$\Rightarrow$ defines position $g = g^*$: Maxwell construction

BARRIER STRUCTURE

Barrier width

$$\left|\nabla E_r\right| = \sqrt{\frac{2F(E_r)}{\mu_{eff}}} \Rightarrow r - r_L = \pm\int_{E_L}^{E_r} dE_r \sqrt{\frac{\mu_{eff}}{2F(E_r)}}$$

$$\delta^{-1} \sim \left|\frac{\nabla E_r}{E_r}\right| = \left|\frac{1}{E_r}\sqrt{\frac{2F(E_r)}{\mu_{eff}}}\right|$$

Assume radial current is due to bulk viscosity (i.e. non-ambi-polar ion plateau flux)

$$J_r \sim \frac{qn_i m_i}{RB^2} E_r \Rightarrow F_{Max} \sim J_r E_r \sim \frac{qn_i m_i}{RB^2} E_r^2$$

$$\Rightarrow \frac{2F_{Max}}{\mu_{eff}} \sim \frac{v_{th,i}}{\mu_i Rq} E_r^2 \Rightarrow \delta \sim \sqrt{\frac{\mu_i Rq}{v_{th,i}}}$$

BARRIER TIME CONSTANT

Poloidal force balance

$$\frac{\varepsilon_0 \varepsilon_\perp}{e}\frac{\partial E_r}{\partial t} = J_r^{Local} \sim \frac{q n_i m_i}{RB^2} E_r$$

$$\Rightarrow \frac{\partial E_r}{\partial t} \sim \frac{1}{M_{eff}}\left(\frac{v_A^2}{\varepsilon_0 c^2}\frac{q v_{th,i} m_i n_i}{RB^2}\right) E_r$$

$$\Rightarrow \tau_{tr} \sim \frac{M_{eff}}{q^2}\frac{qR}{v_{th,i}};$$

Collisional case: $M_{eff} = (1 + 2q^2) \Rightarrow \tau_{tr} \sim (1 + 2q^{-2})\frac{qR}{v_{th,i}}$

Banana regime: $M_{eff} = \frac{q^2}{\varepsilon^2} \Rightarrow \tau_{tr} \sim \frac{qR}{\varepsilon^2 v_{th,i}}$