RMP-Flutter-Induced Pedestal Plasma Transport

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Issue To Be Addressed:

RMP-flutter-induced plasma transport\(^1\) in H-mode pedestal tops.\(^2\)

Theses:

- Flow-screening averts stochastic\(^3\) but not flutter\(^1\) transport.
- RMP-flutter-induced e transport model has been developed.\(^2,4\)
- RMP-flutter transport\(^1\) might cause observed pedestal transport.\(^2\)
- Model implications are different at low\(^5\) and high\(^6\) collisionality.

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RMPs Reduce DIII-D Pressure Gradient At Pedestal Top

- RMP-induced reductions in $|\vec{\nabla} P|$ are:
  - small in core,
  - largest at the pedestal top, $(0.93 < \Psi_N < 0.97)$,
  - small (increase!?) at the edge.

- Key transport issue for ELM suppression is:
  How do RMPs reduce $|\vec{\nabla} P|$ at the pedestal top?

Figure 1: Experimental pressure profile wo/with RMP ELM suppression. Courtesy of O. Schmitz, R. Nazikian, 2011. Indicated rational surface locations are approximate.
How RMPs Suppress ELMs Is Not Yet Understood

- Initial hypothesis\(^5\) was that RMPs induce overlapping islands, magnetic stochasticity and Rechester-Rosenbluth\(^3\) transport.

- But flow-screening\(^7\) by extant toroidal flow in pedestals inhibits RMP "penetration," magnetic island formation & stochasticity — see Figs. 4 and 5 on p 16 and 17 at the end of this poster.

- Recent hypothesis\(^8\) is RMPs induce an island slightly inward of the pedestal top which blocks inward expansion of the pedestal.

- RMP-induced magnetic flutter can induce additional radial electron transport\(^2,4\) and reduce \(\vec{∇}P\) throughout the pedestal top.

- This paper explores RMP-flutter-induced electron density and heat transport and its effects at the top of H-mode pedestals.

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\(^5\) JDC/IAEA FEC poster TH/P4-20 — 8–13 October 2012, p 3
RMPs Induce Radial Flutter Of Magnetic Field Lines

- Between thin islands on rational surfaces, RMP fields cause sinusoidal radial \((x, \rho)\) motion (“flutter”) of magnetic field lines:

\[
\vec{B} \equiv \vec{B}_0 + \delta \vec{B}, \quad \hat{e}_\rho \cdot \delta \vec{B} = \delta \hat{B}_{m/n} \cos(m\theta - n\zeta), \quad \zeta = q(\rho) \theta = (m/n)\theta + xq'\theta,
\]

integrating field line equation \(dx/d\ell = \left(\delta \hat{B}_{m/n}/B_0\right) \sin[k_{\parallel}(x)\ell] \), with \(\ell \equiv R_0 q \theta \), \(k_{\parallel}(x) \equiv -k_\theta x/L_S\), \(k_\theta \equiv m/\rho\), \(x \simeq \rho - \rho_{m/n}\) and \(L_S \equiv R_0 q^2/(\rho q') = R_0 q/s\) (magnetic shear length) yields

\[
x(\ell) \simeq x_0 + \delta x(\ell), \quad \text{in which} \quad \delta x(\ell) = \sum_{m,n} \frac{\delta \hat{B}_{m/n}(x_0)}{B_0} \frac{2}{k_{\parallel}(x_0)} \sin[k_{\parallel}(x_0)\ell].
\]

- Between rational surfaces the RMP-induced radial extent of sinusoidal radial variations of the “fluttering” field lines is

\[
2 \max\{\delta x\} = \frac{\delta \hat{B}_{m/n}(x_0)}{B_0} \frac{2}{k_{\parallel}(x_0)} \sim 5 \text{ mm}.
\]

- See Fig. 5 on p 17 at end of this poster for plot of radially fluttering field lines between isolated chains of magnetic islands.
RMP-Flutter Induces Electron Thermal Diffusivity

- Phenomenological plasma transport diffusivities $D$ are
  \[ D \sim \frac{(\Delta x)^2}{2 \Delta t}, \quad \text{for radial steps } \Delta x \text{ taken in a collision time } \Delta t \sim 1/\nu_e. \]

- Electron collision damping at rate $\nu_e$ is critical for irreversibility.

- When electron collision length $\lambda_e \equiv v_{Te}/\nu_e$ is larger than $1/k_\parallel(x)$, which occurs outside thin layers around rational surfaces,
  \[ \text{for } k_\parallel(x)\lambda_e > 1, \quad \Delta x \sim \frac{1}{k_\parallel} \frac{\delta \hat{B}_{\rho m/n}}{B_0} \implies D_{\text{RMP}} \sim \frac{\nu_e}{2 k_\parallel(x)^2} \left[ \frac{\delta \hat{B}_{\rho m/n}(x)}{B_0} \right]^2, \]

  which is applicable for $|x| > \delta_\parallel \equiv \frac{L_S}{k_\theta \lambda_e} \sim 0.5 \text{ mm} \quad \text{— off rational surfaces.}$

- $D_{\text{RMP}} \sim (1/x^2) \delta \hat{B}_{\rho m/n}(x)^2 \sim \text{constant between rational surfaces since flow-screened } \delta \hat{B}_{\rho m/n}^{\text{pl}}(x) \sim |x| \text{ outside layer of width } \delta_\parallel.$
Collisional electron heat conduction along \( \mathbf{B} = \mathbf{B}_0 + \delta\mathbf{B} \) produces Braginskii parallel electron heat flux \( \tilde{q}_e\parallel \equiv - (n_e \chi_e\parallel / B^2) \nabla B \cdot \nabla T_e \).

Ideal MHD requires \( \mathbf{B} \cdot \nabla T_e = 0 \) to lowest order for \( |x| \gg \delta\parallel \), which causes usual collisional \( q_e\parallel \) to vanish off rational surfaces.

However, kinetic-based irreversible electron collisions plus RMP flutter\(^1,2,4\) cause electron thermal diffusivity \( \chi^B_e \propto \chi^{\text{eff}}_e\parallel \left( \delta B_\rho / B_0 \right)^2 \).

Cylindrical\(^2\) and toroidal\(^4\) models of \( \chi^{\text{eff}}_e\parallel \) have been developed.

The most relevant kinetic-based low collisionality toroidal model:\(^4\)

uses a Lorentz collision model,
accounts for parallel flows only being carried by untrapped particles,
resolves a collisional boundary layer in velocity space, and
includes near-separatrix toroidal geometry and finite aspect ratio effects.
RMP-Flutter Induces Electron Transport Fluxes

- Toroidal model\(^4\) RMP-flutter-induced radial transport fluxes of electron density \(\Gamma_{et}^{\text{RMP}} \equiv \langle \vec{\Gamma}_{et} \cdot \vec{\nabla} \rho \rangle\) and heat \(\Upsilon_{et}^{\text{RMP}} \equiv \langle \vec{q}_{et} \cdot \vec{\nabla} \rho \rangle\) are

\[
\begin{bmatrix}
\Gamma_{et}^{\text{RMP}} \\
\Upsilon_{et}^{\text{RMP}}/T_e
\end{bmatrix} = -n_e \begin{bmatrix}
D_{et}^{\text{RMP}} & D_T^{\text{RMP}} \\
\chi_n^{\text{RMP}} & \chi_{et}^{\text{RMP}}
\end{bmatrix} \cdot \begin{bmatrix}
d \ln \hat{p}_e/d\rho \\
T_e \ln T_e/d\rho
\end{bmatrix}, \quad \frac{d \ln \hat{p}_e}{d\rho} = \frac{d \ln p_e}{d\rho} - \frac{e}{T_e} \frac{d \Phi_0}{d\rho},
\]

in which the total RMP-induced diffusivities are summed over all the \(m, n\) components:

\[
\begin{bmatrix}
D_{et}^{\text{RMP}} & D_T^{\text{RMP}} \\
\chi_n^{\text{RMP}} & \chi_{et}^{\text{RMP}}
\end{bmatrix} = \sum_{mn} \begin{bmatrix}
D_{et}^{m/n} & D_T^{m/n} \\
\chi_n^{m/n} & \chi_{et}^{m/n}
\end{bmatrix} \equiv \frac{v_T^2}{v_e} \frac{1}{2} \sum_{mn} \left( \frac{\langle \delta \hat{B}_{\rho m/n}^\text{pl} \rangle}{B_{t0}} \right)^2 \begin{bmatrix}
K_{00} & K_{01} \\
K_{10} & K_{11}
\end{bmatrix}.
\]

The kinetically-derived Padé-approximate \(K_{ij}\) matrix of coefficients are defined by\(^4\)

\[
\begin{bmatrix}
K_{00} & K_{01} \\
K_{10} & K_{11}
\end{bmatrix} = c_K \begin{bmatrix}
G_{00} & G_{01} \\
G_{10} & G_{11}
\end{bmatrix}, \quad \text{with coefficient } c_K \equiv \frac{B_{t0}/B_{\text{max}}}{\langle v ||\lambda=1/v \rangle} \frac{13}{24\pi},
\]

in which the matrix \(G_{ij}(x)\) of dimensionless, spatially-dependent geometric coefficients are

\[
\begin{bmatrix}
G_{00} & G_{01} \\
G_{10} & G_{11}
\end{bmatrix} = \frac{4}{13} |X|^{3/2} \left( \frac{|X|^{3/2}}{c||t} \int_0^{1/|X|^{1/2}} dy \ y^3 e^{-y} + \int_{y_{\text{min}}}^{\infty} dy \ e^{-y} \right) \begin{bmatrix}
1 & y - \frac{5}{2} \\
y - \frac{5}{2} & (y - \frac{5}{2})^2
\end{bmatrix}, \quad c||t = \frac{(3/16)(B_{t0}^2/B_{\text{max}}^2)}{f_c \langle v ||\lambda=1/v \rangle},
\]

\(y_{\text{min}} \equiv \max\{1/|X|^{1/2}, 1/|X_{\text{crit}}|^{1/2}\}\) and the normalized radial distance from \(m/n\) rational surface is

\[
X \equiv \frac{x}{\delta||t} = \frac{q(\rho) - m/n}{q' \delta||t} \sim \frac{\rho - \rho_{m/n}}{\delta||t}, \quad \text{in which } \delta||t \equiv c_t \frac{L_S}{k\theta \lambda e}, \quad \text{with } c_t \equiv 3\sqrt{\pi} \langle v ||\lambda=1/v \rangle |B_{\text{max}}/B_{t0}|.
\]

\(JDC/IAEA FEC\) poster TH/P4-20 — 8–13 October 2012, p7
RMP Fluxes Have Diverse Parameters And Properties

• In low collisionality DIII-D plasmas in which RMPs suppress ELMs, typical pedestal top parameters at $\Psi_N \simeq 0.95$ are

$$T_e \simeq 1130 \text{ eV}, \quad n_e \simeq 2.5 \times 10^{19} \text{ m}^{-3}, \quad Z_{\text{eff}} \simeq 1.7, \quad \lambda_e \simeq 350 \text{ m}, \quad v_{Te}/\nu_e \simeq 7 \times 10^9 \text{ m}^2\cdot\text{s}^{-1}, \quad \langle \delta B_{\rho m/n}^{\text{vac}} \rangle / B_{t0} \simeq 3.34 \times 10^{-4}, \quad B_{\text{max}} / B_{t0} \simeq 4/3, \quad \langle v_\parallel |\chi_{\lambda=1/v} \rangle \simeq 0.45, \quad c_K \simeq 0.29, \quad X_{\text{crit}} \equiv (2/3 \sqrt{\pi}) (B_{t0}/B_{\text{max}}) (\lambda_e/\rho_0 q) \simeq 17, \quad c_{||t} \simeq 0.94, \quad c_t \simeq 3.2, \quad L_S \simeq 2.4 \text{ m}, \quad k_\theta \simeq 15 \text{ m}^{-1}, \quad \rho_{11/3} - \rho_{10/3} \simeq 1/nq' \simeq 2.8 \text{ cm and } \delta_{||t} \simeq 1.5 \text{ mm}.$$

• RMP-flutter-induced radial transport fluxes:

are Onsager-symmetric for thermodynamic forces $d \ln \hat{p}_e / d\rho$ and $d \ln T_e / d\rho$,

include contributions both inside dissipative layer and outside ($|x| \gg \delta_{||t}$) it,

have parallel diffusivities that decrease as $|x|^{-3/2}$ due to collisional boundary layer and are large near rational surfaces but smaller between them,

have larger thermal than density diffusivities ($\chi_{et}^{m/n}/D_{et}^{m/n} \simeq 3.25$),

have negative off-diagonal components ($D_T^{m/n}/D_{et}^{m/n} \simeq \chi_n^{m/n}/\chi_{et}^{m/n} \simeq -3/2$) off of rational surfaces ($|x| \gg \delta_{||t}$) due to thermal and frictional forces.
More Effects Are Included In Comparisons To Data

• Requiring electron particle flux to be ambipolar yields a reduced effective electron thermal diffusivity \( \chi_{e\,\text{eff}}^{m/n} \) for \( |x| \gg \delta_{||t} \):

\[
\Gamma_{et}^{m/n} = -n_e \left( D_{et}^{m/n} \frac{d \ln \hat{p}_e}{d \rho} + D_T^{m/n} \frac{d \ln T_e}{d \rho} \right) \to 0 \implies \frac{d \ln \hat{p}_e}{d \rho} = -\frac{D_T^{m/n}}{D_{et}^{m/n}} \frac{d \ln T_e}{d \rho},
\]

which yields effective electron thermal diffusivity off rational surfaces:

\[
\chi_{e\,\text{eff}}^{m/n} = \chi_{et}^{m/n} \left[ 1 + \left( \frac{\chi_{m/n}}{\chi_{et}} \right) \left( -\frac{D_T^{m/n}}{D_{et}^{m/n}} \right) \right] \approx \frac{4}{13} \chi_{et}^{m/n} — \text{factor of } 4/13 \text{ smaller.}
\]

• Magnetic island of width \( W \) modifies \( \chi_{e\,\rho}^{m/n} (\rho) \) near rational surface:

preceding analysis is only valid outside island, \( x_0 \gg W/4 \equiv [\delta \hat{B}_{\rho\,m/n} L_S / k\theta B_0]^{1/2} \),

effective radial electron thermal diffusivity near island will be estimated by

\[
\chi_{e\,\rho}^{m/n} \approx \frac{1}{1 - F_{m/n}^W(x)} + \frac{F_{m/n}^W(x)}{\chi_{e\rho}^{m/n}}, \quad F_{m/n}^W(x) = \begin{cases} 0, & |x| < W/4 \\ \frac{|x| - W/4}{W/4}, & W/4 \leq |x| \leq W/2 \\ 1, & |x| > W/2 \end{cases},
\]

in which \( \chi_{e\,\rho}^{m/n} \sim \infty \) is thermal diffusivity across island region.
$T_e$ Profile Between $m/n$ Surfaces Is Caused By $\chi_{eW_{\text{eff}}}(\rho)$

- Model flow-screened RMPs with
  \[
  \delta \hat{B}_{\rho m/n}^{\text{pl}}(x) = \delta \hat{B}_{\rho m/n}^{\text{vac}} \left( \frac{1}{f_{\text{scr}}^2} + \frac{x^2}{L_{\delta B}^2} \right)^{1/2}, \quad L_{\delta B} \simeq 2.5 \text{ cm},
  \]
  with flow-screening factor $f_{\text{scr}} \equiv \frac{\delta \hat{B}_{\rho m/n}^{\text{vac}}(0)}{\delta \hat{B}_{\rho m/n}^{\text{pl}}(0)}$.

- Parameters for Figs. 2 and 3 are $f_{\text{scr}} = 4$ and $W \simeq 1.5 \text{ cm}$.

- $\chi_{eRMP}^{\text{RMP}}$ (dashed) and $\chi_{eW_{\text{eff}}}^{\text{RMP}}$ (solid) obtained by adding 10/3 and 11/3 contributions are shown in Fig. 2.

- Resultant $T_e$ profile is in Fig. 3.

- Dotted lines in Figs. 2 and 3 show radially-averaged $\overline{\chi}_{e\text{RMP}}$ from $\Delta T_e/\Delta \rho$.
**Radially-Averaged $\overline{\chi}_e^{\text{RMP}}$ Is Comparable To DIII-D Data**

- While large $\chi_e^{\text{RMP}}$ at rational surfaces flattens the $T_e$ profile there, average $dT_e/d\rho$ is determined mainly by the minimum diffusivity — radial heat flow is like resistors with impedance $1/\chi_e$ in series.

- Radially-averaged $\overline{\chi}_e^{\text{RMP}} \simeq 1.15 \text{ m}^2 \cdot \text{s}^{-1}$ with islands is larger than $\chi_e^{\text{sym}} \simeq 0.6 \text{ m}^2 \cdot \text{s}^{-1}$, which should reduce $dT_e/d\rho$ at pedestal top.

- However, it is smaller than the experimental $\chi_e^{\text{RMP}} \simeq 4 \text{ m}^2 \cdot \text{s}^{-1}$.

- Predicted $\overline{\chi}_e^{\text{RMP}}$ would be larger if
  
  other $m/n$ contributions are included (usually small effect), or

  flow-screened RMP fields $\delta\hat{B}_{\rho m/n}^{\text{pl}}$ obtained from extended MHD codes such as M3D-C1$^{7\text{c,e}}$ are used in the diffusivity evaluations, which are underway$^9$ — see last 3 viewgraphs at the end of this poster.

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Radial Electric Field Is Determined By Torque Balance

- Since RMP-induced ion density flux $\sim \nu_i$ is smaller by a factor of $(m_e/m_i)^{1/2} \sim 1/60$, RMPs induce a radial current $J^{\text{RMP}}_\rho < 0$.

- Non-ambipolar (na) radial density fluxes cause\textsuperscript{10} toroidal torque densities ($T_\zeta \equiv \bar{e}_\zeta \cdot \vec{F}_{\text{force}}$ where $\bar{e}_\zeta \equiv R^2 \vec{\nabla} \zeta = R \hat{e}_\zeta$) on the plasma:

\[
T_\zeta = -q_s \langle \bar{\Gamma}_s^{\text{na}} \cdot \vec{\nabla} \psi_p \rangle = -q_s \langle \bar{\Gamma}_s^{\text{na}} \cdot \vec{\nabla} \rho \rangle \psi'_p \quad \text{— function of } E_\rho \equiv -|\vec{\nabla} \rho| d\Phi_0/d\rho.
\]

- Ion & electron 3D density fluxes cause oppositely directed torques:

$\bar{\Gamma}_i^{\text{na}}$ (NTV, ripple) create\textsuperscript{10d} counter-current torques because $q_i = + e$ ($J_\rho > 0$),

but RMP electron density fluxes create co-current torques because $q_e = - e$.

- Torque density equation for $L_t \equiv m_in_i \langle R^2 \rangle \Omega_t$ sums all torques:\textsuperscript{10}

\[
\frac{\partial L_t}{\partial t} \mid_{\text{inertia}} \approx - \langle \bar{e}_\zeta \cdot \vec{\nabla} \cdot \bar{\pi}_{3\text{D}} \rangle + \langle \bar{e}_\zeta \cdot \delta \vec{J} \times \delta \vec{B} \rangle - \langle \bar{e}_\zeta \cdot \vec{\nabla} \cdot \bar{\pi}_{i\parallel} \rangle - \frac{1}{V'} \frac{\partial}{\partial \rho} (V' \Pi_{i\rho \zeta}) + \langle \bar{e}_\zeta \cdot \sum_s \bar{S}_{sm} \rangle \cdot \text{mom. sources}
\]

\textsuperscript{10a} J.D. Callen, A.J. Cole and C.C. Hegna, Nucl. Fusion 49, 085021 (2009); \textsuperscript{b} J.D. Callen, A.J. Cole and C.C. Hegna, Phys. Plasmas 16, 082504 (2009); \textsuperscript{c} J.D. Callen, C.C. Hegna and A.J. Cole, Phys. Plasmas 17, 056113 (2010); \textsuperscript{d} J.D. Callen, Nucl. Fusion 51, 094026 (2011).
Ambipolar Constraint Predicts Radial Electric Field

- RMP-flutter-induced toroidal torque density is
  \[
  \langle \vec{e}_\zeta \cdot \delta \vec{J}_u \times \delta \vec{B}_\rho \rangle = e \Gamma_e^{RMP} \psi' = -\frac{n_e m_i}{\rho_S^2 / R^2} \sum_{mn} D_{et}^{m/n} (\Omega_t - \Omega_{e*}), \quad \frac{\rho_S^2}{R^2} = \frac{T_e / m_i}{e^2 \psi_p^2 / m_i^2},
  \]
  \[
  \Omega_{e*} \equiv -\frac{1}{e} \left( \frac{1}{n_e} \frac{dp_e}{d\psi_p} + \frac{1}{n_i} \frac{dp_i}{d\psi_p} + \frac{D_T^{m/n}}{D_{et}^{m/n}} \frac{dT_e}{d\psi_p} \right) + \Omega_p \sim -\frac{1}{n_e e R B_p} \frac{dP}{d\rho} > 0.
  \]

- If this torque is dominant, RMP-induced electron flux vanishes
  \[\implies\] ambipolarity constraint, \( \Omega_t \simeq \Omega_{e*} \) and radial electric field:
  \[
  \vec{E}_0 \equiv -\nabla_\rho \frac{d\Phi_0}{d\rho} \simeq -\nabla_\rho \frac{T_e}{e} \left( \frac{d \ln p_e}{d\rho} - \frac{3}{2} \frac{d \ln T_e}{d\rho} \right).
  \]

- These “electron root” predictions are consistent with DIII-D data:\(^{11}\)
  radial electric field changes from \(-\) to \(+\) for \( \Psi_N < 0.93 \), and
  \( \Omega_t \) “jumps” to \( \Omega_{e*} \simeq 10 \text{ kRad} \cdot \text{s}^{-1} \) at \( \Psi_N \simeq 0.95 \) when\(^{4,11}\) RMPs suppress ELMs.

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RMP Effects Are Different At High Collisionality

- ASDEX-U electron collision frequency $\nu_e$ is $\gtrsim 10$ greater which
  1) increases shear-effects width parameter by a factor $\sim 10$ to $\delta_\parallel \gtrsim 2$ cm,
  2) causes most “smoothing” processes to exceed half the distance between rational surfaces and hence overlaps the effects around various $m/n$ surfaces $\implies q_{95}$ resonance effects and magnetic islands are less likely.
  3) reduces bootstrap current and possibly $\delta B^\text{pl}_{\rho m/n}$ RMP responses.
  4) makes transition to “electron root” unlikely because $m/n$ effects overlap and increased edge NBI momentum input makes usual ion root more robust.

- Model predictions for approximate ASDEX-U conditions are:
  1) $\chi^\text{RMP}_e \sim \nu_e L^2_S \sum_{mn} \left[ \frac{\delta B^\text{vac}_{\rho m/n}}{B_0} \right]^2 \gtrsim 1 \text{ m}^2/\text{s}, \quad L_S \equiv \frac{R_0 q_s}{s} \text{ magnetic shear length}$,

  2) which reduces gradients throughout pedestal if it exceeds a typical level of $D_\eta \sim \eta/\mu_0 \sim \nu_e \delta_e^2$ transport there and yields an ELM mitigation criterion:

$$\delta_e^2 \equiv \frac{c^2}{\omega_{pe}^2} \approx \frac{3 \times 10^{19}}{n_e (\text{m}^{-3})} 10^{-6} \lesssim L^2_S \sum_{mn} \left[ \frac{\delta B^\text{vac}_{\rho m/n}}{B_0} \right]^2 \implies n_e \gtrsim 5 \times 10^{19} \text{ m}^{-3}?$$
SUMMARY: RMP-Flutter Transport Is New Paradigm

- New model for RMP-flutter-induced electron density and heat fluxes (p 7) has been developed and is beginning to be tested.\(^2,4,9\)

- Requiring density flux to be ambipolar yields predictions for effective thermal diffusivity (p 9) and pedestal electric field (p 13).

- Effects of thin islands at rational surfaces are estimated (p 9).

- Fig. 2 shows while \(\chi_{eRMP}^e\) in low collisionality pedestals is largest at rational surfaces, Fig. 3 shows \(\Delta T_e\) between them and \(\bar{\chi}_{eRMP}^e\) depend mainly on minimum diffusivity midway between surfaces.

- Model predictions agree semi-quantitatively with DIII-D results — for \(\bar{\chi}_{eRMP}^e\), average \(dT_e/d\rho\) and \(E_\rho\) at pedestal top.

- RMP-flutter-induced transport could reduce pedestal top |\(\nabla P\)|, limit its expansion and stabilize P-B instabilities, suppress ELMs.
• RMP-induced $m/n$ fields:
  
  are reduced from vacuum values on rational surfaces,
  
  by flow-screening factor $f_{\text{scr}}$, but
  
  grow $\sim$ linearly away from them.

• Parameters of the highlighted 11/3 RMP field are

  $f_{\text{scr}} \sim 10$,

  $L_{\delta B} \sim 0.02 \, a$

  $\sim 1.6 \, \text{cm}$. 

Figure 4: Flow-screened RMP-induced $\langle \hat{B}_{\rho \, m/n}^{\text{pl}} \rangle$. Courtesy of N.M. Ferraro, O. Meneghini and S.P. Smith 2012.
Plasma Response To RMPs Creates Radially Isolated Island Chains With Magnetic Flutter Between Them

Figure 5: Poincare plots of field lines with vacuum RMP fields (left) and with flow-screened RMP plasma response fields (right) from M3D-C1 $\langle \delta \hat{B}_{rpm/n} \rangle$ shown in Fig. 4. Figures courtesy of D. Orlov, R.A. Moyer and N.M. Ferraro, 2012.
Flutter Model $\chi_e$ and $T_e$ Profiles Using Preceding RMP Fields Are Consistent With Experimental Profiles

- Figures courtesy of S.P. Smith, P.T. Raum (NUF student), N.M. Ferraro and O. Meneghini (see reference 9 on p 11).

Figure 6: Electron thermal diffusivity profiles for the two flutter models in the edge of DIII-D discharge 126006.

Figure 7: Corresponding $T_e$ profiles for the two flutter models in the edge of DIII-D discharge 126006.