Understanding and controlling density pump-out will improve the viability of RMP ELM control in ITER.

- Pedestal $n_e$ decrease plays a significant role in stabilization of Peeling-Ballooning modes.
- But core $n_e$ decrease reduces stored energy and core performance ($Q_{\text{fus}}$ in ITER).
- Need physics understanding and predictive capability for RMP-induced transport in ITER and other next step devices.

L. Zeng UCLA Poster JP6.00075
Increasing ELM suppression resonant window $\Delta q_{95}$ without increasing stochastic layer width $\Delta \psi_N$ is desirable for ITER

- The $n=4$ ITER RMP coil design has greater spectral flexibility than the DIII-D I-coil
  - Expected to provide larger $\Delta q_{95}$ with smaller edge stochastic region width

T.E. Evans GA Poster JP6.00070
Density pump-out in DIII-D H-modes has a broader resonance $\Delta q_{95}$ than ELM suppression.

- For $q_{95} = 3.5$ in the resonant window for ELM suppression, density pump-out scales with I-coil current.
- For $q_{95} = 4.5$ outside the resonant window, pump-out is similar to $q_{95} = 3.5$ despite lack of ELM suppression.
- For $q_{95} = 5.5$, pump-out is dramatically reduced.
Density pump-out in DIII-D H-modes has a broader resonance $\Delta q_{95}$ than ELM suppression.

- For $q_{95} = 3.5$ in the resonant window for ELM suppression, density pump-out scales with I-coil current.
- For $q_{95} = 4.5$ outside $\Delta q_{95}$ resonant window, pump-out is similar to $q_{95} = 3.5$ without ELM suppression.
- For $q_{95} = 5.5$, pump-out is dramatically reduced.

![Graph showing waveforms with q95 values and density, I-coil current, and time (ms) axes.]
Density pump-out in DIII-D H-modes has a broader resonance $\Delta q_{95}$ than ELM suppression.

- For $q_{95} = 3.5$ in the resonant window for ELM suppression, density pump-out scales with I-coil current.
- For $q_{95} = 4.5$ outside $\Delta q_{95}$ resonant window, pump-out is similar to $q_{95} = 3.5$ without ELM suppression.
- For $q_{95} = 5.5$, pump-out is dramatically reduced but not eliminated.
SOLPS modeling suggests that pump-out is due to particle transport changes, not just recycling or pumping changes

- Matching the shape of outboard mid-plane profiles requires changing the particle diffusivity, not just the pumping efficiency or recycling coefficient.
- Particle transport changes are consistent with stochastic field diffusion based on vacuum field model TRIP3D

Fits to outboard mid-plane $n_e$ profiles

Comparison of inferred diffusivities

SOLPS modeling: S. Mordijck, Paper JP6.00074
The RMP induces electron losses from the pedestal consistent with the vacuum magnetic field structure

- Calculate the splitting of the inner divertor magnetic footprint using the TRIP3D vacuum magnetic field model.
- The floating potential $V_f$ becomes strongly negative during RMP ELM suppression, consistent with loss of higher temperature electrons from the pedestal [J.G. Watkins, et al., PSI08 in press]
Plasma potential changes are consistent with vacuum field modeling of laminar (flux loss) zone.

- Plasma potential becomes positive during RMP for $\psi_N \geq 0.97–0.98$
- Typical laminar zone width in TRIP3D simulations is $\psi_N \geq 0.97$

O. Schmitz, FZJ Poster JP6.00069
Ambipolar potential in 3D perturbed equilibrium induces ion losses that follow the vacuum magnetic field footprints

- Particle flux footprint at inner strike point as measured by $D_\alpha$ emission shows multiple peaks at location of magnetic field line footprint as calculated with TRIP3D vacuum field model.
XGC0 kinetic equilibrium evolution code reproduces self-consistent neoclassical $E_r$ in the experiment

- XGC0 is a full-f ion/electron/neutral, kinetic equilibrium evolution code:
- 3D B-field topology, but plasma potential is solved as a function of radius only
- With an ad hoc screening factor on vacuum RMP, reproduces many features of RMP H-modes

XGC0 simulation results

Experimental results

XGC0: G. Park, C.S. Chang, NYU Poster JP6.00133
XGC0 reproduces many features of RMP H-modes with an ad hoc screening factor for the vacuum RMP

- XGC0 calculates neoclassical transport with self-consistent $E_r$ in realistic geometry
- Pedestal profiles after 60 ion transit times $\tau_b \approx 4$ ms in experiment show qualitative features seen in stationary experimental profiles:
  - At $60\tau_b$, $E_r$ is stationary, but transport and profiles are still evolving

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G. Park, C.S. Chang, NYU Poster JP6.00133
Ion scale fluctuations increase broadband across a wide radial extent \(0.65 < \rho < 1\) when ELMs suppress.

- Similar behavior seen at intermediate scales \((k_\theta \approx 4-5 \text{ cm}^{-1})\)

**BES@r/a=0.95**

- **I-COIL ON**
- **ELM Suppression**

**BES Spectra:** \(\langle I \rangle < \langle n/n \rangle\)

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**BES:** McKee UW

**Correlation reflectometer:** L. Schmitz UCLA
Edge resonant magnetic perturbations suppress ELMs by enhancing particle transport across plasma.

- Pedestal particle transport increase aids stabilization of Peeling-Ballooning modes by reducing pedestal pressure gradient, *but*
- Enhanced core particle transport decreases stored energy more than desired in ITER
  - Need to understand the particle transport in order to optimize the pedestal transport while minimizing the core transport
- RMP establishes a 3D equilibrium with significant flux loss (laminar) zone
  - Evidence for laminar zone from floating potentials at target plates and mid-plane plasma potential changes
- Neoclassical transport in 3D equilibrium leads to enhanced ion transport
  - Particle flux profiles agree with magnetic footprints from vacuum field model
  - Calculated pedestal profiles from XGC0 qualitatively similar to experiment
- Core density is effected by 1.5-2x higher broadband turbulence during RMP across a wide radial extent $0.65 < \rho < 1$ due to $E_r$ shear changes
- Improving radial localization of flux loss (laminar zone) will provide P-B stabilization while minimizing core transport increase
  - New inner wall “S coils” will provide this in DIII-D