Effect of 3-D Fields on Particle Transport

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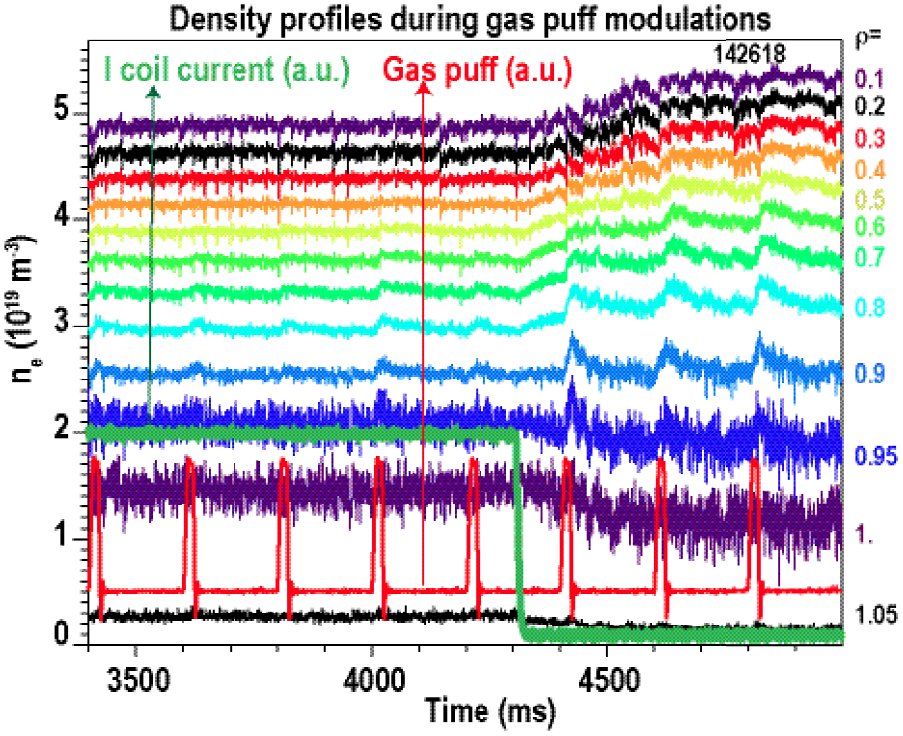
- **Particle transport experiments on DIII-D (2010, Zeng & Doyle)**
  - Utilizes modulated edge particle source with gas puff
  - Modulation of electron density profile from fast-swept reflectometry
    - > n_e=0.2-3.5x10^{13} cm^{-3}, Δt>4 μs resolution
  - Ohmic and NB-heated L-mode, NB-heated H-mode
  - Detailed measurements across outboard minor radius (ρ=0.0-1.0)
- **Similar experiments planned for NSTX (FY2012 JRT)**
  - Modulate edge particle source with gas puff using SGI
    - > Similar to method used on DIII-D in 2010
    - > Analysis by Takenaga (JT-60U) assumes cylindrical symmetry
  - Use ultrafast-swept frequency reflectometers
    - > Look at density profile modulation and turbulence response
- **RMP component to experiments on DIII-D**
  - Add RMP with stead I-coil current (n=3, even parity), gas puff modulation
    - > Diffusion coefficient increases, inward pinch decrease (increased particle transport)
    - > Both L- and H-mode
  - Density also modulated using I-coil
    - > Analysis in progress

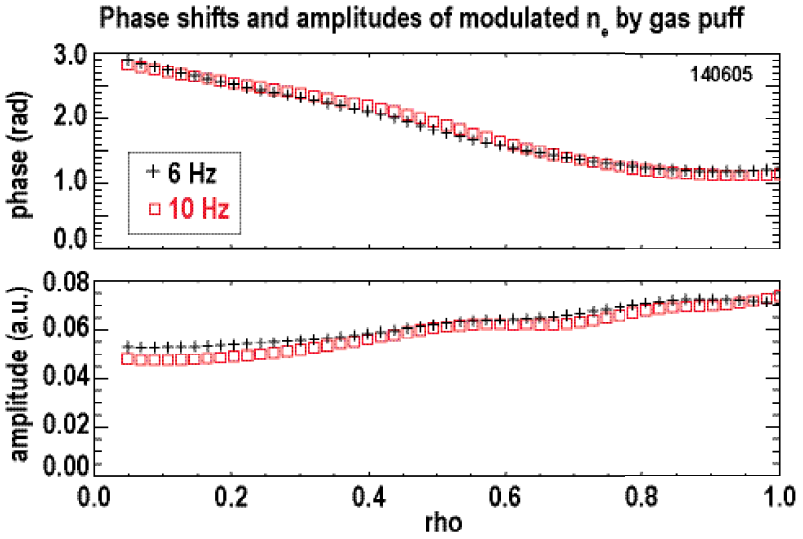
RMPs in L-Mode

- Use RMP with shots developed for L-mode particle transport XP
  - Connection with turbulence (e.g., evidence of turbulence change w. Li)
  - Current hardware limited to density range below 3.5×10^{13} cm^{-3}
  - SGI puffs into L-mode with RMPs for particle transport
  - RMP pulses into L-mode
  - Could be run fairly early
  - 1/2 day or less of run time and/or XMP time for FY2012 JRT
  - Direct comparison with DIII-D L-mode results
- H-mode
  - Some limited coverage with Q-band system might be possible
  - Requires DIII-D V-band system
    - > Could be delivered after end of DIII-D run (October 2011?)
  - Extends frequency range to 72 GHz
    - > $n_e = 0.2\text{-}6.4 \times 10^{13}$ cm^{-3}
  - Probably requires significant repackaging for NSTX
  - Could be available January 2012
- Requires considerable resources and planning.
- Need to know soon whether this will be worth the effort.

Backup: Example of Technique and Analysis

L-mode w/ and w/o RMP





Assume local perturbation: $\tilde{n} = A(r)\sin(\omega t - \phi(r))$

Assume cylindrical symmetry, modulated transport equations yield:

$$D = -\frac{\omega(X+Y)\sin(\phi)}{r\dfrac{\partial\phi}{\partial r}A}$$

$$v = -\frac{\omega\left(\dfrac{\partial A}{\partial r}Y - \dfrac{\partial\phi}{\partial r}AX\right)\sin(\phi) + \left(\dfrac{\partial\phi}{\partial r}AY + \dfrac{\partial A}{\partial r}X\right)\cos(\phi)}{r\dfrac{\partial\phi}{\partial r}A^2}$$

$$X = \int_0^r r\,A\cos(\phi)dr$$

$$Y = \int_0^r r\,A\sin(\phi)dr$$

Backup: Transport Increases With RMP