Developing the steady state, high-Z wall, high-field tokamak for ITER and beyond
Many more C-Mod results at this meeting

- Invited talks:
  - John Rice, *Rotation in C-Mod*, Monday AM, BI2-01
  - Eric Edlund, *Reverse Shear Alfven Eigenmodes during Sawteeth*, Tuesday AM, GI1-03
  - Rachael McDermott, *Edge $E_r$ and H-Mode*, Wednesday AM, NI1-02
  - Bruce Lipschultz, *Hydrogen Retention in High Z PFCs*, Thursday AM, TI2-01
  - John Wright, *Full Wave Effects on LH Waves*, Thursday PM, VI2-03

- Contributed Orals (now)
- Contributed Posters – Wednesday PM (session PP6)
- ITER Contributed Oral Session – Tuesday AM (session GO3)

WEB: www.psfc.mit.edu/research/alcator/pubs/APS/index.html
First Demonstrations of ICW Flow Drive in ICRF Mode-Conversion Experiments

- **Active ICRF Flow Drive**
  - At least a factor of 2 above the usual scaling seen with pressure/current
- **Use multi-frequency capability**
  - 80 MHz, proton minority
  - 50 MHz, $^3$He mode conversion
  - Both layers near the axis
- **Near-axis conversion to Ion Cyclotron Wave (ICW)**
  - propagates back toward low field side
  - damps and drives flow at $^3$He cyclotron layer
  - Regime is relevant to D-T scenarios (ITER)

**Mode Conversion Flow Drive**

$B(R_0) = 5.1$ Tesla; $^3$He fraction $\sim 10\%$

**Diagram**

- Toroidal Velocity (km/s)
- $\Delta$ Stored Energy/$I_p$ (kJ/MA)

Yijun Lin BI2-06
Lower Hybrid Pedestal Modification

- Addition of LHCD into H-mode
  - Increases pedestal temperature (electrons and ions)
  - Decreases pedestal density
- Collisionality substantially reduced
- Prompt change in edge fluctuations, Lyman-alpha
  - Particle transport enhanced
Strong correlation between H-mode $E_r$ well-depth and confinement

- ~mm-resolution rotation profile diagnostics
  - Toroidal and poloidal
  - Detailed $E_r$ profiles
- Pedestal height (and thus $\tau_E$) increase monotonically with $E_r$ well-depth
- $E_r$ well width is not a strong function of other parameters

J.W. Hughes, PP6-83
R. McDermott, NI1-02
Improved “L”-mode (I-mode):
H-mode $\tau_E$, L-mode $\tau_P$

- Conditions to access I-mode
  - Unfavorable $\nabla B$ drift
  - Stay just below threshold for transition to conventional H-mode (up to x3 in power)
- Strong edge energy barrier
- Weak particle barrier (density control, no impurity accumulation)
- No ELMs
- Low collisionality pedestal
- $H_{\text{ITER-98}} \sim 1$
- ITER applicability?

R. McDermott, NI1-02
J.W. Hughes, PP6-83
RSAEs driven during sawteeth

- Reverse-Shear Alfven Eigenmodes appear after sawtooth crash
  - Measured with Phase Contrast Imaging ($\delta n_e$) and external magnetics (n-spectrum)
  - RSAE driven by fast protons (ICRF hydrogen minority heating, $E_p \sim 100$ keV)
- NOVA-K simulations (e.g. n=4) give eigenmode structure
  - Synthetic PCI diagnostic in the code shows good agreement with experiment
C-Mod is an excellent test-bed for the study of hydrogenic retention

- Serious concern about tritium retention in ITER
- Tungsten proposed for ITER
- With clean Mo PFCs on C-Mod
  - Retention can be large fraction (up to 50%) of the injected gas
  - Corresponds to > 1% of the flux to the divertor surfaces
- Retention is approximately independent of plasma density
- Independent of heating or confinement mode
Runaway Electron Production during Mitigated Disruptions

- On C-Mod, use LHCD seed population of non-thermal electrons
- Inductive spike accelerates electrons to runaway energies at thermal quench
- Massive Gas Puff mitigation
  - Strong MHD leads to prompt loss before runaways build to large fraction of $I_P$

R. Granetz, GO3-13
Mitigation is effective because convected energy from central plasma is dissipated by radiation in the extremely cold and dense edge.

Resulting plasma is highly stochastic → runaway electron loss.

NIMROD resistive MHD simulations: Cooling induced non-ideal MHD in edge leads to central thermal quench without particle penetration.

100 keV electrons accelerate (>1 MeV) and then are lost.

Induced MHD causes B-field to become stochastic.

R. Granetz, GO3-13
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