Burning Plasma-related Presentations at APS-DPP
November 12-16, 2007
Orlando, FL

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Monday, November 12, 2007 9:30AM - 12:30PM
Session BI1 Pedestal, SOL and Divertor
Rosen Centre Hotel Junior Ballroom

10:00AM BI1.00002 Effect of Island Overlap on ELM Suppression by Resonant Magnetic Perturbations in DIII-D M.E. Fenstermacher for the DIII-D Team, Lawrence Livermore National Laboratory — Recent DIII-D experiments show that the degree of magnetic island overlap in the plasma edge is a good predictor for suppression of edge-localized modes (ELMs), consistent with theoretical expectations. For fixed resonant magnetic perturbation (RMP) strength, ELM suppression is obtained over a finite window in the edge safety factor (*q95*) indicating a resonant effect. In H-mode plasmas, ELM suppression is obtained over an increasing range of *q95* by either increasing the RMP strength that produces the islands, or by adding n =1 perturbations to "fill in" islands across the edge plasma. Large Type-I ELMs are completely suppressed by applying n = 3 RMPs in the presence of n =1 error-field correction and small n = 2 and 3 field-error components in plasmas with electron pedestal collisionality of ~0.1 and shape similar to ITER. In these experiments, the region of island overlap is changed by varying either: 1) the strength of the applied n = 3 RMP, 2) the edge q-profile, 3) the combination of n = 3 and n =1 perturbations, or 4) the up-down parity of the applied n = 3 RMP. Each case agrees with theoretical expectations that the island overlap region width (vacuum fields) needs to be at least several times the width of the pedestal to completely eliminate ELMs. Theory predicts that the plasma response in rotating plasmas reduces the RMP amplitude from the vacuum level (RMP screening). Experiments to validate this theory have examined the detailed dependence of ELM suppression on the width of the island overlap region for two different values of edge toroidal rotation. Experimental validation of theoretical models for ELM suppression represents an important scientific advance that will provide the foundation for designing ELM control systems in future devices. [1]Supported by US DOE under W-7405-ENG-48 and DE-FC02-04ER54698.

10:30AM BI1.00003 Influence of Beta, Shape, and Rotation on the H-mode Pedestal Height in DIII-D, A.W. LEONARD, General Atomics — Recent experiments on DIII-D aimed at improving our understanding of the H-mode pedestal have shown that the observed pedestal gradient and pedestal width are sensitive to variations in plasma shape and global but relatively insensitive to plasma rotation. These dependencies are critical to the extrapolation of present results to ITER due to the sensitivity of fusion performance on pedestal height. Using single parameter scans to isolate these effects, the pedestal pressure was observed to increase as either plasma shaping or global was increased due to an increase in the width and the gradient of the pedestal pressure. In both cases, stability analysis indicated that the increased pressure gradient is consistent with peeling/ballooning theory. Stronger shaping increases the edge stability limit, allowing the pedestal pressure gradient to increase. At the same time, the pedestal width grows with the increasing pressure gradient until the MHD stability limit is reached and an ELM occurs. In the same manner, increased improves the edge stability limit through increased Shafranov shift, with the pedestal gradient and width increasing. The increase in pedestal width at higher total pedestal pressure is correlated with a larger ion gyroradius as suggested by a number of theories. Gyroradius dependence will be examined with respect to previous results and scaling of the pedestal height to ITER. Increased toroidal rotation was observed to have minimal impact on the pedestal height even though core energy confinement improved. Increased toroidal rotation does not significantly change the stability limit, resulting in the pedestal width and gradient remaining unchanged. These results suggest that the improvement in core confinement as rotation increases is independent of pedestal performance. Supported by US DOE under DE-FC02-04ER54698.

Monday, November 12, 2007 9:30AM - 12:30PM
Session BO3 Beams, Instabilities, and Turbulence
Rosen Centre Hotel Salon 9/10

10:18 AM BO3.00005 **Further Development of the Gyrotron- Powered Pellet Accelerator**, FRANCIS PERKINS, University of Colorado — The Gyrotron-Powered Pellet Accelerator provides an enabling technology to efficiently fuel ITER with fast pellets launched from the High Field Side (HFS) separatrix. Pellet experiments have repeatedly found that fuel efficiently is high - consistent with 100%. In contrast, Low Field Side (LFS) launch experiments find efficiencies of 50% or less. This report addresses what experimental program and what material choices can be made to retain program momentum. An initial program seeks to establish that our heterogeneous approach to conductivity works, maintaining s 1 mho/m. A demonstration of acceleration can be carried out in a very simple laboratory when the pusher material D_2[Be] is replaced by LiH[C] which is a room temperature solid with a graphite particle suspension. No cryogenics or hazard chemicals. The mm-wave mirror will be graphite, the tamper is sapphire, and the payload LiD. The payload has a pellet has diameter = 3mm and a mass M = 4.4×10^{-4} kg which is 220 joules at V=1000 m/s. A barrel length of 15 cm completes the design specification.

Monday, November 12 2007 2:00pm- 5:00pm
Session CP8 Poster Session II: Reconnection and Non-Neutral I; Spheromaks and MCX; MFC Diagnostics; Simulation: Algorithm; Simulation: Kinetic/Edge
Rosen Centre Hotel Grand Ballroom

CP8.00075 **Fast ion collective Thomson scattering (CTS) diagnostic results at TEXTOR, ASDEX Upgrade and status of ITER design**, S.K. NIELSEN, Risoe-DTU/PSFC MIT, H. BIND-SLEV, S.B. KORSHOLM, F. LEIPOLD, P. MICHELSEN, Risoe-DTU, P. WOSKOV, PSFC MIT, J.W. OOSTERBEEK, IPP-FZ Juelich, E. WESTERHOF, FOM, F. LEUTERER, D. WAGNER, IPP-Garching, TEXTOR TEAM, ASDEX TEAM — In ITER, fast alpha particles born in fusion processes will account for up to 70% of the heating power. Measurements of confined fast ions resolved in space, pitch angle, energy and time are needed to support improvements of current theories. Fast ion collective Thomson scattering (CTS) can meet this need. Here we present results from CTS on TEXTOR where a 150 KW 110GHz gyrotron scatters off fluctuations driven by NBI/ICRH fast ions. The 1D fast ion velocity distribution has been inferred, where the resolved direction and the measuring volume are defined by the scattering geometry. The spatial resolution is ~10 cm while the temporal resolution is 4 ms. The build-up and slowdown of co-injected neutral beams are reported along with comparisons between co and counter beam ion dynamics. The measured decay and build-up of co NBI is in agreement with classical slowing down. First results from ASDEX Upgrade, where a 105 GHz system is installed are expected to be presented. Finally, the status of the 60 GHz CTS diagnostic design proposed for ITER is presented. Supported by U. S. DoE and EURATOM.

CP8.00084 **Development of free-standing diffractive optical elements as light extractors for burning plasma experiments**, D. STUTMAN, G. CARAVELLI, M. FINKENTHAL, A. TOLEA, G. WRIGHT, D. WHYTE, N. MOLDOVAN — Optical diagnostics will be critical for the operation and performance assessment of burning plasma experiments, such as ITER. At the same time, extracting light for these diagnostics with reflective mirrors becomes difficult in the burning plasma environment, due to prolonged exposure to plasma and nuclear radiation. As an alternative, we explore free-standing diffractive optical elements, such as transmission gratings and zone plates. Since in the case of diffractive extractors the light is deflected by periodic slits rather than a surface, they may withstand plasma exposure with less degradation of their optical properties. To investigate this possibility we developed free-standing transmission gratings for the visible range and exposed them in to conditions resembling or exceeding those expected for the ITER `first mirrors'. The results of this study indicate that the gratings can withstand high heat fluxes and plasma and energetic radiation bombardment. In addition, in contrast to the reflective elements, the extraction capabilities of the diffractive elements can also improve with plasma exposure, due for instance to shaping and thinning of the grating bars by plasma erosion. Supported by US DoE grant DE-FG02-99ER54523.

Tuesday, November 13, 2007 9:30AM - 12:30PM
Session GO3 DIII-D Tokamak
Rosen Centre Hotel Salon 9/10

9:30AM GO3.00001 **Overview of Recent DIII-D Experimental Results**, C.M. GREENFIELD, General Atomics, DIII-D NATIONAL TEAM — The 2007 DIII-D experimental campaign focuses on resolving issues of importance to the ongoing ITER Design Review. Recent experiments have established the importance of island overlap for ELM suppression and confirmed the previous observation of a low rotation threshold for RWM stabilization in AT plasmas with $\beta_N \approx 4$, providing critical information for the design of internal coil systems for RWM and ELM control in ITER. Experiments simulating the ITER startup scenario with an outer wall limited plasma exhibit high internal inductance during the current ramp, potentially presenting challenges for vertical stability in ITER. Studies performed in the high performance hybrid scenario establish that pedestal pressure increases with triangularity and plasma β, but with little dependence on plasma rotation. Increasing T_e/T_i with ECH results in increased low to intermediate k fluctuations, but little change in confinement. In other studies, radial profiles of electron temperature and density fluctuations have been simultaneously measured, and are observed to behave similarly. Supported by the US DOE under DE-FG02-04ER54698.

9:42AM GO3.00002 Effects of Resonant Magnetic Perturbations on Edge Turbulence and Profiles in DIII-D, J.A. BOEDO, D.L. RUDAKOV, I. JOSEPH, R.A. MOYER, UCSD, G.R. MCKEE, U. Wisc-Madison, D. REISER, Juelich, T.E. EVANS, W.P. WEST, GA, J.G. WATKINS, SNL — Resonant magnetic perturbations (RMPs) applied to the plasma edge can cause changes in average density and in the turbulence measured by various diagnostics at the edge and scrape-off layer (SOL). The change in turbulence can modify the edge profiles, which can affect the RMP ELM suppression, which is important for ITER. Two main regimes have been explored: 1) low power and collisionality discharges, where it is seen that the RMPs affect the edge profiles across the SOL and into the core; and 2) high power, varying (low, medium and high) collisionality discharges where the average density can increase or decrease but the turbulence in the SOL always increases. In these discharges, the pedestal fluctuations can increase or decrease in narrowly localized radial regions near the pedestal top. When the RMP are rotated toroidally, the fluctuations change amplitude and/or location, indicating that the RMP-induced changes are toroidally localized. Supported by US DOE under DE-FG02-04ER54698, DE-FG02-89ER53296, DE-FC02-04ER54758, and DE-AC04-94AL85000.

9:54AM GO3.00003 Resistive Wall Mode and Plasma Stability at High β and Slow Rotation, A.M. GAROFALO, H. REIMERDES, M.J. LANCTOT, Columbia U., M. OKABAYASHI, H. TAKAHASHI, PPPL, G.L. JACKSON, R.J. GROEBNER, R.J. LA HAYE, E.J. STRAIT, GA, Y. IN, J. KIM, FAR-TECH, Inc. — DIII-D experiments extended the observation of resistive wall mode (RWM) stabilization by slow plasma rotation to various scenarios, including high-β advanced tokamak scenarios, and confirmed that magnetic feedback increases stability against equilibrium disturbances, such as large ELMs. At high β, magnetic disturbances that resonant with marginally stable RWM can lead, depending on torque input and momentum confinement, to loss of torque balance followed by plasma locking, perturbation growth, and confinement loss. Reconnection may take place once plasma is locked. Magnetic feedback can maintain or quickly restore axisymmetry and avoid locking. With very low torque input, however, error field threshold for locking may be below feedback sensitivity. Residual uncorrected error fields may explain why minimum sustainable rotation profiles are generally higher than those predicted by ideal-plasma RWM stability theory. Supported by the US DOE under DE-FG02-89ER53297, DE-AC02-76CH03073, DE-FC02-04ER54698, and DE-FG02-03ER83657.

10:06AM GO3.00004 Plasma Initiation and Startup in DIII-D Simulating the ITER Scenario, G.L. JACKSON, T.C. LUCE, J.R. FERRON, A.W. HYATT, T.W. PETRIE, W.P. WEST, GA, T.A. CASPER, LLNL, E.A. LAZARUS, ORNL, R.A. MOYER, D.L. RUDAKOV, UCSD — DIII-D similarity experiments have investigated the ITER baseline startup scenario, specifically outer wall low field side (LFS) limited discharges with an I_p ramp at constant safety factor, q95. Optimizing startup may be necessary for ITER advanced tokamak (AT) discharges and to minimize limiter heating. Although I_p initiation in DIII-D occurred near the inner wall (in the region of highest $E_\phi L$, where E_ϕ is the inductive electric field and L is the wall connection length), it moved outward in <5 ms (scaling to ~0.25 s in ITER) and then limited on the LFS limiters. In this ITER-like shape, I_p was ramped to ≤1.2 MA with q95 held constant during the limited phase by a simultaneous I_p and κ ramp. In addition to presenting LFS startup results, we will discuss other startup issues for ITER, i.e. limiter heat flux, compatibility with AT scenarios, sawteeth, and vertical stability. Startup scenarios other than constant q95 will also be presented. Supported by the US DOE under DE-FC02-04ER54758, W-7405-ENG-48, DE-AC05-00OR22725, and DE-FG02-094ER54758.

10:18AM GO3.00005 High Performance Operation on DIII-D With Reduced Frequency of Wall Conditioning, W.P. WEST, N.H. BROOKS, A.W. HYATT, G.L. JACKSON, C.M. GREENFIELD, P.A. POLITZER, M.R. WADE, General Atomics, M. GROTH, LLNL — Recent DIII-D experiments have demonstrated the capability to obtain high performance plasmas, ($\beta_N H_{ITER89}/q^2_{95}$ ~0.38), in both hybrid and steady-state scenarios over an extended operations period (6000 plasma seconds) with no intervening boronization or bakes. Over the same period, impurity influx monitored with daily reference shots remains at low levels. With adequate divertor pumping, good hybrid performance can also be maintained in several sequential discharges with no between-shot helium glow. These findings on DIII-D, which has >95% graphite plasma facing wall, are in sharp contrast to recent studies on tokamaks with high-Z metallic walls, where frequent boronizations are found necessary to prevent radiative collapse of high-confinement, high-beta discharges [1,2]. [1] B. Lipschultz, et al., Phys. Plasma 13, 056117 (2006). [2] R. Neu, et al., J. Nucl. Mater. 363-365, 52 (2007). Supported by the US DOE under DE-FC02-04ER54698 and W-7405-ENG-48.

10:30AM GO3.00006 Observation of Carbon Dust in the DIII-D Divertor and SOL, D.L. RUDAKOV, A.YU. PIGAROV, R.D. SMIRNOV, J.H. YU, UCSD, W.P. WEST, C.P.C. WONG, GA, M. GROTH, M.E. FENSTERMACHER, LLNL, W.M. SOLOMON, PPPL— Dust accumulation is a serious safety concern for ITER. In DIII-D carbon dust is observed in divertor and scrape-off layer (SOL) by optical imaging. After an extended entry vent, thousands of dust particles are observed in the first 2-3 plasma discharges. Individual particles moving at velocities up to ~500 m/s, and breakup of larger particles into pieces are observed. After ~70 discharges, dust levels are reduced to a few observed events per discharge except in discharges with disruptions that produce significant amounts of dust. Using the divertor materials evaluation system (DiMES), micron-sized carbon dust is injected into DIII-D ELMing H-mode discharges. When the outer divertor strikepoint is swept onto DiMES, ~2% of the dust carbon content penetrates the core, raising the core carbon density by a factor of ~4. Dust particles from the injection are observed in the outboard SOL. The observed dust trajectories and velocities are in qualitative agreement with the modeling of the 3D

DustT code. Work supported by US DOE under DE-FG02-04ER54758, DE-FC02-04ER54698, W-7405-ENG-48, DE-AC02-76CH03073.

10:42AM GO3.00007 Extension of DIII-D Hybrid Plasmas Towards Operation with $T_e \sim T_i$ and Low Rotation, E.J. DOYLE, University of California-Los Angeles, THE HYBRID SCENARIO THRUST TEAM — DIII-D hybrid plasmas typically operate in a hot ion mode ($T_i > T_e$) with high plasma rotation, which tend to reduce turbulent transport. Recent DIII-D experiments extend hybrid operation to more reactor relevant conditions, with low plasma rotation and $T_e \approx T_i$. Using electron cyclotron (EC) heating to replace part of the neutral beam heating, T_e/T_i has been increased to ~0.8 in hybrid plasmas with β_N=2.6, with minimal effect on confinement time and a modest reduction in plasma rotation. The plasma turbulence level increased significantly in the EC heated hybrid plasmas, at both low and intermediate wavenumbers, as measured by BES and FIR scattering systems. Central Mach number in DIII-D hybrid plasmas has been scanned across a wide range, from 0.07 to 0.6. At low rotation, the confinement factor H_{89} degrades, typically by 10%-30%. Transport modeling using the GLF23 code indicates that the change in transport with rotation can be accounted for by changes in the ExB shearing rate. 1Work supported by US DOE under DE-FG03-01ER54615 and DE-FC02-04ER54698.

10:54AM GO3.00008 Towards Demonstration of Steady-State High-Performance Scenarios in DIII-D, T.C. LUCE, J.R. FERRON, P.A. POLITZER, C.M. GREENFIELD, A.W. HYATT, G.L. JACKSON, T.W. PETRIE, R.I. PINSKER, W.P. WEST, GA, A.M. GAROFALO, R. REIMERDES, Columbia U., T.A. CASPER, C.T. HOLCOMB, M.A. MAKOWSKI, LLNL, M. OKABAYASHI, PPPL, M. MURAKAMI, J.M. PARK, ORNL, E.J. DOYLE, UCLA, S. IDE, JAEA — Experiments on advanced scenarios in DIII-D are focused on extension to the resistive time scale, optimization, and exploration for higher performance. Optimization studies use ECCD and counter-NBI to modify the q profile shape, looking at the effect on MHD stability and bootstrap current. Feedback control of the current formation is also a key element of optimization. Closed-loop experiments and modeling of open-loop tests have been carried out. Experiments seeking β_N=5 used two approaches – high q_{min} with rotational stabilization and high magnetic shear. High shear experiments achieved $\beta_N > 4.5$ transiently. Attempts to use the longer-pulse (5 s) ECCD system to extend the duration of noninductive high-performance discharges to resistive equilibrium will be presented. Supported by the US DOE under DE-FC02-04ER54698, DE-FG02-89ER53297, W-7405-ENG-48, DE-AC02-76CH03073, DE-AC05-00OR22725, and DE-FG03-01ER54615.

Tuesday, November 13, 2007 9:30AM - 12:30PM
Session GP8 Poster Session III: Turbulence, Transport, and NL Processes; Fast Ignition and Laser-Plasma Interactions; Divertors, Edge Physics and Fueling; MHD Theory, Heating and Current Drive; Simulation: MHD; Optimal Helicon Source Performance
Rosen Centre Hotel Grand Ballroom

GP8.00115 AEGIS-GK: Gyrokinetic Investigation of Resistive Wall Mode Stability, L.J. ZHENG, M. KOTSCHENREUTHER, J.W. VAN DAM, Institute for Fusion Studies, Univ. of Texas -Austin — The stability of resistive wall modes (RWM) is an issue of concern for burning plasma confinement, e.g., in ITER. The kinetic resonances, as well as the shear Alfvén resonance, have been shown to be important for RWM stability. However, due to the complexity of kinetic effects, only hybrid models with partial kinetic effects have so far been used to investigate RWM stability. The success in recovering full MHD with our newly derived gyrokinetic theory [Phys. Plasmas **14**, 072505 (2007)] now allows the possibility to study RWMs in a self-consistent kinetic manner. We will present our scheme for a gyrokinetic treatment of RWMs and also analyze various kinetic effects. In particular, we will demonstrate that the parallel electric field, missing in conventional kinetic treatments, cannot be ignored in studying the effects of wave-particle resonances on RWMs. Also, we will show how the kinetic resonances and the shear Alfvén resonance can couple with each other. Preliminary numerical results from the AEGIS-GK code, which incorporates the new gyrokinetic theory, will be also presented. Research supported by Department of Energy Grant DE-FG02-04ER54742.

GP8.00088 Divertor and Confinement Issues for Next-Step Devices, M. KOTSCHENREUTHER, PRASHANT VALANJU, SWADESH MAHAJAN, Institute for Fusion Studies — Next step devices operating in advanced tokamak (AT) modes include proposed experiments (including NHTX and FDF), Component Test Facilities (CTFs), and ITER. We present an analysis of the likely scrape-off layer widths and heat loads on the divertors for such devices. We include analysis of novel divertor configurations including X-divertors and stochastic edge. The connection between divertor modifications and core plasma confinement is also examined. Work supported by DOE Grant DE-FG02-04ER54742, and by ICC Grant DE-FG02-04ER54754.

Tuesday, November 13, 2007 2:00PM - 5:00PM
Session JI1 Waves and Energetic Particles
Rosen Centre Hotel Junior Ballroom

2:00PM JI1.00001 **Excitation of Alfvén Eigenmodes by Low Velocity Beam Ions in the JET and DIII-D Tokamaks**, R. NAZIKIAN, Princeton Plasma Physics Laboratory — New data on the DIII-D and JET tokamaks reveal a rich variety of Alfvénic activity excited by neutral beam ions traveling at only a small fraction of the local Alfvén velocity. These observations challenge our detailed understanding of the excitation of Alfvénic phenomena and provide a validation platform for testing fundamental theoretical predictions. In addition, precise internal measurements of density and temperature fluctuations reveal new information on the kinetic properties of Alfvén eigenmodes that challenge ideal MHD descriptions of these instabilities. Recent experiments on the JET facility with 3.5 T magnetic field and low plasma density demonstrate that Cascade modes are excited by 50 keV beam ions corresponding to only $v_A/6$, where v_A is the local Alfvén velocity. Toroidal Alfvén eigenmodes are excited by ions traveling at only $v_A/4$, well below the $v_A/3$ sideband condition for the primary resonance. Detailed stability analysis reveals a key role played by finite orbit effects and in particular the beam ion anisotropy for these low energy excitations. Similarly, studies on DIII-D with 2.0 T magnetic fields reveal that the direction of injection of neutral beam injection is a critical factor in the excitation of Alfvén eigenmodes. As in JET, a key to directional sensitivity is the finite orbit width of the fast ions. New observations are also obtained on the excitation of n=0 modes in both JET and DIII-D driven by low energy (50-80 keV) beam ions. Internal measurements reveal much smaller temperature-to-density fluctuation levels for these modes, suggesting that the fluctuations cannot be interpreted as due to the radial displacement of magnetic field lines. Supported by US DOE under DE-AC02-76CH03073 and DE-FC02-04ER54698 and the EFDA JET program.

2:30PM JI1.00002 **Alfvén Cascade modes at high β_e in the National Spherical Torus Experiment--structure and suppression,** N. A. CROCKER, UCLA — Beam ions and/or fusion alphas are expected to excite Alfvén Cascade (AC) modes (i.e. reversed-shear Alfvén eigenmodes) in ITER reversed-shear advanced scenarios. The National Spherical Torus eXperiment (NSTX), where fast-ions with comparable $v/v_{\_Alfvén}$ (~ 2 - 4) excite ACs, is an ideal device in which to observe ACs and their impact. Its wide range of β_e (ratio of electron to magnetic pressure) enables tests of AC theory up to, and beyond, a critical β_e where suppression is predicted. A value for critical β_e, ~ $1/[4*q_{min}o2(1+(7/4)(T_i/T_e))]^{-1}$, may be derived from the theory of Breizman, et al. [Phys. Plasmas 12 (2005) 112506]. Observations of suppression and frequency evolution in NSTX, including onset and saturation, agree well with this theory and calculations by the NOVA-K linear stability code. The dependence of AC frequency on minimum safety factor (q_{min}) enables a sensitive determination of q_{min} from the AC spectrum that agrees well with the minimum of the q profile measured using the motional Stark effect. AC structure measurements near critical β_e from three fixed frequency (i.e. spatially localized) reflectometers and three tangential interferometers show a structure consistent with predicted localization near the q_{min} radius. Magnetic measurements indicate shear-wave polarization at q_{min}. Fast-ion response is monitored with neutral particle analyzers, a fast lost ion probe and neutron detectors. Profile measurements of q, density, electron and ion temperature, and rotation are used by NOVA-K to predict mode structure and frequency, or suppression, for direct comparison with the mode measurements. These novel observations of ACs near critical β_e are well explained by theory, allowing us to extrapolate our understanding of this physics with confidence.

3:30 PM JI1.00004 **ICRF performance with Metallic Plasma Facing Components: Revenge of the Sheath** S. WUKITCH, MIT — Ion cyclotron range of frequency (ICRF) heating is expected to provide auxiliary heating for ITER and future fusion reactors where high Z metallic plasma facing components (PFCs) are envisioned. The advantages of ICRF heating is the availability of relatively inexpensive high power sources and it can directly heat ions. For coupling, the antenna needs to be close to the plasma and antenna operation can be limited by compatibility (impurity generation, density production and erosion). Utilizing high Z PFCs, control of ICRF generated impurities becomes more important because the acceptable fractional high Z material concentration in the plasma is of order 1000 times less than low Z materials. In addition, low Z coatings applied in-situ, ie boronization, is often utilized to mitigate the high Z impurities in the plasma. However, erosion of these typically thin, low Z coatings will limit their effective lifetime. In Alcator C-Mod, we have investigated the compatibility of high power ICRF heating with high performance plasmas and high-Z PFCs with and without boronization. With boronization, record C-Mod stored energy and world record plasma pressures were achieved with 5.25 MW of injected ICRF power. However, impurity control through boronization is temporary and boronization appears to erode 3-5 times faster with ICRF compared with Ohmic H-modes. Experimental evidence suggests that RF-enhanced sheaths on open field lines are responsible for enhanced erosion and impurity influx. Utilizing localized boronization, we have determined that the primary impurity source is outside the divertor and we demonstrated that the erosion location is linked to the active antenna. Furthermore, we observed that erosion rate associated with ICRF heating was unaffected by the heating scenario's single pass absorption. Using a 3-D antenna code coupled to a full wave solver we will present the influence antenna geometry has upon sheaths and possible mitigation strategies. Work supported by US DoE Cooperative agreement DE-FC02-99ER54512.

Tuesday, November 13, 2007 2:00PM - 5:00PM
Session JP8 Poster Session IV: Education and Outreach; Undergraduate Research; Electron and Ion Beam/Space Charge; DIII-D I; Reversed Field Pinches; Energetic Ions and Electrons in Helicons
Rosen Centre Hotel Grand Ballroom

JP8.00013 Electrostatic dust detector with improved sensitivity, D.P. BOYLE, Columbia University, C.H. SKINNER, A.L. ROQUEMORE, Princeton Plasma Physics Laboratory — Measurement of dust inventories in next-step fusion devices will be necessary to ensure compliance with safety regulations. A device for detection of dust on remote surfaces, consisting of an ultrafine grid of interlocking copper traces biased to 30-50V, has been developed and tested[1]. Impinging dust particles produce temporary short circuits and the resulting current pulses are recorded using nuclear counting electronics. A digital oscilloscope was used to analyze the current pulse waveform under various experimental conditions in order to enhance the sensitivity of the device. Preliminary results indicate an order of magnitude increase in sensitivity to carbon dust particles is possible. This would enable the detector to measure the low levels of dust (~5 ng/cm^2/shot) produced in NSTX. Results will be presented from both small 12x12 mm and large 50x50 mm detectors, using both carbon and tungsten dust. [1] C.V. Parker et al., J. Nucl. Mater., 363-365 (2007) 1461. Support is provided by the U.S. DOE Contract No. DEAC02-76CH03073 and the 2007 National Undergraduate Fellowship Program in Plasma Physics and Fusion Energy Sciences.

JP8.00069 Transport of fast ions modulated by shear Alfvén waves, YANG ZHANG, HEINZ BOEHMER, WILLIAM HEIDBRINK, ROGER MCWILLIAMS, UC Irvine, TROY CARTER, DAVID LENEMAN, STEPHEN VINCENA, BRIAN BRUGMAN, WALTER GEKELMAN, UCLA, UC Irvine Team, UCLA Collaboration — The interaction of fast particles with Alfvén instabilities is important in magnetic fusion devices and natural plasmas. In this experiment, shear Alfvén waves (SAW) modulate fast ion transport through Doppler shifted cyclotron resonance, in addition to the classical collisional diffusion. A Li+ ion source is inserted in the LArge Plasma Device (LAPD) with ion energy up to ~2000 eV, detected by a collimated fast ion energy analyzer. RF antennas launch waves with amplitude of \delta B/B ~ 0.1% that propagate along the machine axis. When launched in (out of) phase with the perpendicular wave electric field, fast ions gain (lose) energy from (to) the wave. A ~10% increase in the beam radial width and beam signal modulation at SAW frequency are observed. These fast ion transport phenomena peak near the predicted resonance condition. ($\omega_{Alfvén} - k_z v_z = \omega_{fast-ion}$). Work supported by DOE DE-FG02-03ER54720.

JP8.00074 Recent DIII-D Research in Support of ITER, M.R. WADE, General Atomics, DIII-D National Team — The DIII-D research team has made several recent contributions that are impacting the design of key components for ITER. Using criteria determined from recent DIII-D experiments showing the importance of island overlap in the edge, researchers have evaluated various non-axisymmetric coil configurations for ITER. DIII-D experiments have established criteria for stabilization of the most serious instabilities in ITER: resistive wall modes (RWMs) and neoclassical tearing modes (NTMs). Analysis suggests that a small level of toroidal rotation is sufficient to stabilize RWMs even at β_N=4. DIII-D experiments were instrumental in the choice of an improved ECCD mirror design for ITER, enabling the ability to simultaneously stabilize the m=3/n=2 and m=2/n=1 NTMs with ~10 MW in ITER. Recent studies on DIII-D simulating the current ramp phase in ITER indicate a risk of peaked current density profiles and an associated susceptibility to vertical instability. Results of other research on disruption mitigation using massive gas injection and on the choice of plasma facing materials in ITER will also be presented. Work supported by the US DOE under DE-FC02-04ER54698.

JP8.00075 Understanding Magnetic Field Error Correction in DIII-D, M.J. SCHAFFER, R.J. LA HAYE, E.J. STRAIT, General Atomics, J-K. PARK, J.E. MENARD, PPPL, A.H. BOOZER, Columbia U. — A comparison was made between the measured DIII-D magnetic field error and an ideal MHD plasma response model. New measurements of TF coil errors reduced the bounds of unknown errors. Empirical error corrections for DIII–D standard left-handed-pitch plasmas were refined, and a new empirical correction was developed for right-handed-pitch plasmas. Empirical corrections were analyzed by the new Ideal Perturbed Equilibrium Code, which computes the linear free-boundary plasma response to prescribed external error and/or correction fields in real geometry. This analysis explained the paradox of why the DIII-D C-coil empirical correction is ~3 times the error field on a vacuum field basis: the plasma strongly modifies the error and correction fields differently, and the total fields actually come to partial cancellation. The theory provides guidance for error correction with imperfectly matched fields. Separately, a short proof of principle experiment showed that further improvement (locked mode avoidance) is possible if the remaining TF coil current feed error were reduced. Work supported by U.S. DOE under DE-FC02-04ER54698.

JP8.00081 Study of RWM Stabilization by Plasma Rotation Using Active MHD Spectroscopy, H. REIMERDES, A.M. GAROFALO, M.J. LANCTOT, G.A. NAVRATIL, Columbia U., M.S. CHU, G.L. JACKSON, R.J. LA HAYE, E.J. STRAIT, General Atomics, Y. LIU, Chalmers U., M. OKABAYASHI, PPPL — Active MHD spectroscopic measurements have been used to probe the stability of the n=1 and n=2 kink modes in various DIII-D scenarios. The response of the plasma to externally applied slowly rotating non-axisymmetric fields, measured with magnetic field sensors, yields damping rates and mode rotation frequencies. The measurements show the transition from an ideal MHD stable plasma to a weakly damped resistive wall mode (RWM) at the ideal MHD, no-wall stability limit. Active MHD spectroscopy also tests kinetic theory, which is thought to be responsible for the observed RWM stabilization by plasma rotation. In contrast to measurements of the rotation threshold, which is likely caused by a nonlinear interaction of residual error fields with the weakly damped RWM, the spectroscopic technique at sufficiently low amplitude can be directly compared to linear predictions. Supported by the US DOE under DE-FG02-89ER53297, DE-FC02-04ER54698, and DE-AC02-76CH03073.

JP8.00082 Challenges for Robust Feedback Stabilization of ELM-Driven Resistive Wall Mode (RWM), M. OKABAYASHI, H. TAKAHASHI, PPPL, A.M. GAROFALO, H. REIMERDES, M.J. LANCTOT, Columbia U., G.L. JACKSON, R.J. LA HAYE, E.J. STRAIT, GA, Y. IN, J. KIM, FAR TECH Inc. — The RWM can be stabilized by modest plasma rotation. However, even when plasma rotation is well above the critical value, MHD activities such as ELMs and Fishbones excite RWMs. Feedback plays several crucial roles against RWM onset. Minimizing the amplification of residual error fields due to MHD events is the first necessary step for providing robust feedback RWM stabilization. Below the no-wall β_N limit, feedback can reduce the residual n=1 RWM amplitude and consequently the amplification is reduced as indicated by the edge T_i. Near the high β_N operational limit, ELM events suddenly increase the amplitude of stable RWM resonating with residual error field, presumably triggered by the n=1 component of ELM or by the rapid change of the RWM mode pattern during ELMs. The existence of finite amplitude leads to fast unstable RWM growth. When the feedback can completely reduce the resonant process, high β plasmas remain stable. Supported by the US DOE under DE-AC02-76CH03073, DE-FG02-89ER53297, DE-FC02-04ER54698, and DE-FG03-99ER82791.

JP8.00083 Excitation of Resistive Wall Mode Instabilities by Transient MHD Events in DIII-D, E.J. STRAIT, G.L. JACKSON, R.J. LA HAYE, General Atomics, M. OKABAYASHI, H. TAKAHASHI, PPPL, A.M. GAROFALO, H. REIMERDES, M.J. LANCTOT, Columbia U., Y. IN, J. KIM, FAR TECH Inc. — The resistive wall mode (RWM) often limits the performance of high-beta plasmas that rely on wall stabilization of low-n kink instabilities. The RWM can be stabilized by plasma rotation, but DIIID experiments show that even discharges with significant rotation are sometimes observed to develop a large-amplitude RWM immediately following an edge-localized mode (ELM) or other transient MHD event. This is thought to be the result of a nonlinear process in which the ELM resonantly drives the stable RWM to a finite amplitude, followed by magnetic braking of the plasma rotation. Open issues include the importance of magnetic shielding by the rotating plasma, the question of whether or not the RWM develops a positive growth rate during this process, and the possible role of scrape-off layer currents. Experimental results will be compared with a simple 0-D model. Supported by the US DOE under DE-FC02-04ER54758, DE-AC02-76CH03073, and DE-FG02-89ER53297.

JP8.00084 Sawtooth Suppression by Tearing Modes in Hybrid Plasmas on DIII-D, C.C. PETTY, P.A. POLITZER, GA, W.W. HEIDBRINK, UCI, R. NAZIKIAN, PPPL, S.L. ALLEN, LLNL — Hybrid discharges have the remarkable property that the m/n=3/2 neoclassical tearing mode (NTM) raises the central safety factor (q_0) above unity and suppresses sawteeth. Experiments on DIII-D are trying to distinguish between several sawtooth suppression mechanisms. One mechanism that can be tested for is the redistribution of the beam ions by the 3/2 NTM, which would increase the off-axis neutral beam current drive (NBCD). The NBCD profile can be determined from the evolution of the poloidal flux measured by motional Stark effect (MSE) polarimetry. Also, the fast ion D_α (FIDA) diagnostic can measure the fast ion density profile for hybrid discharges with and without the 3/2 NTM. Another analysis tool is TRANSP simulations of the current profile evolution, which shows that diffusion of the beam ions is unlikely to raise q_0 above 1. Other possible sawtooth suppression mechanisms are hyper-resistivity, counter current drive in the plasma core via a coupling between the 3/2 NTM and a 2/2 sideband, and magnetic flux pumping. Work supported by US DOE under DE-FC02-04ER54698, SC-G903402, DE-AC02-76CH03073, and W-7405-ENG-48.

JP8.00086 Behavior of Escaping Fast Ions From DIII-D Tokamak, Y.B. ZHU, W.W. HEIDBRINK, University of California, Irvine — The behavior of escaping fast ions from DIII-D Tokamak is investigated. Two pairs of thin foil Faraday collectors provide the energetic ion loss signals from the co/counter plasma current directions. The data are compared with neutron flux and fast ion deuterium alpha (FIDA) measurements. Comparative studies show that the signals are correlated with toroidal field and certain plasma parameters, such as plasma current, loop voltage, temperature and rotation. Further studies on the modulation of prompt ion loss induced by neutral beam injection, and enhanced fast ion loss from ion cyclotron radio frequency and MHD are reported. The secondary electron emission effect, which is believed to be responsible for the negative signal from blind background foil [1], is observed and qualitatively proven by active foil biasing experiments. [1] M. Isobe, et al., Rev. Sci. Instrum. 77, 10F508 (2006). Supported by the US DOE under SC-G903402 and DE-FC02-04ER54698.

JP8.00087 Reversed Shear Alfvén Eigenmode Stabilization by Localized Electron Cyclotron Heating, M.A. VAN ZEELAND, J. LOHR, General Atomics, W.W. HEIDBRINK, University of California, Irvine, R. NAZIKIAN, W.M. SOLOMON, N.N. GORELENKOV, G.J. KRAMER, PPPL, M.E. AUSTIN, U. Texas, T.L. RHODES, UCLA, C. HOLCOMB, M.A. MAKOWSKI, LLNL, G.R. MCKEE, U. Wisconsin, S.E. SHARAPOV, UKAEA — Reversed shear Alfvén eigenmode (RSAE) activity in DIII-D is observed to be stabilized by electron cyclotron heating (ECH) near the minimum of the safety factor (q_{min}) in neutral beam heated discharges with reversed magnetic shear. The degree of RSAE stabilization and the volume averaged neutron production (S_n) are highly dependent on ECH deposition location relative to q_{min}. Ideal MHD simulations predict RSAE existence during ECH, indicating that the mode disappearance is due to kinetic effects not taken into account by the ideal MHD model. While discharges with ECH stabilization of RSAEs have higher S_n than discharges with significant RSAE activity, neutron production remains strongly reduced (up to 60%), indicating the bulk of the deficit is not due to RSAEs alone. Supported by the US DOE under DE-FC02-04ER54698, SC-G903402, DE-AC02-76CH03073, DE-FG03-97ER54415, DE-FG02-01ER54615, W-7405-ENG-48, and DE-FG02-89ER53296.

JP8.00088 Central Flattening of the Fast-Ion Profile in Reversed-Shear Discharges with Alfvén Eigenmode Activity, W.W. HEIDBRINK, Y. LUO, C. MUSCATELLO, UC-Irvine, N.N. GORELENKOV, R.B. WHITE, PPPL, M.A. VAN ZEELAND, GA, G. VLAD, Euratom-ENEA — Neutral beam injection into a plasma with reversed shear produces a rich spectrum of Alfvén eigenmodes (AE) in DIII-D. Application of fast-ion D_α (FIDA) spectroscopy shows that the central fast-ion profile is anomalously flat in the inner half of the discharge. Neutron and equilibrium measurements corroborate the FIDA data. The temporal evolution of the current profile is strongly modified. Calculations by the ORBIT code do not explain the observed fast-ion transport for the measured mode amplitudes. A simulation of this discharge with the HMGC code suggests that transient energetic particle modes may be primarily responsible for the fast-ion transport, while the experimentally obvious toroidal AE (TAE) and reversed shear AE (RSAE) may be relatively unimportant. A search for the predicted energetic particle modes is planned. An empirical study of the correlation of profile flattening with varying amounts of Alfvén activity in different discharges will also be presented. Supported by US DOE under SC-G903402, DE-AC02-76CH03073, and DE-FC02-04ER54698.

JP8.00098 Transport, MHD, and Stability Investigations of a Proposed Fusion Development Facility (FDF), H.E. ST. JOHN, L.L. LAO, C.M. GREENFIELD, R. PRATER, P.B. SNYDER, G.M. STAEBLER, V.S. CHAN, R.D. STAMBAUGH, General Atomics — Recent simulations of a compact next generation testing facility tokamak, FDF, indicates that favorable H-mode, AT-type operation with high boostrap current fractions, is possible. Our simulations assumed an *apriori* fixed, stable edge pressure stable and peeling-ballooning modes and favorably shaped but fixed density profiles. Heating and current drive was supplied by on and off axis ECH and low energy, 120 keV, beams directed near the plasma edge. The resulting rotation speed profile is highly sheared at the plasma edge. Under these conditions we were able to simulate a suite of internal transport barrier confined discharges using the GLF23 transport model with the ONETWO transport code. Ongoing work includes extending these simulations to include fixed boundary MHD calculations, density evolution and dynamic ELM control using the ELITE edge stability code. We present the results and methodology required to perform these simulations. R.E. Waltz, et al., Phys. Plasma 4, 2482 (1997).

JP8.00099 Modeling ITER and DIII-D Current Ramps for Startup Similarity Experiments, T.A. CASPER, W.H. MEYER, L.D. PEARLSTEIN, LLNL; G.L. JACKSON, J.R. FERRON, A.W. HYATT, T.C. LUCE, T.W. PETRIE, W.P. WEST, GA; M. MURAKAMI, ORNL; R.A. MOYER, D.L. RUDAKOV, UCLA — We have begun similarity experiments on DIII-D to validate ITER startup scenarios and to explore possible alternatives. Reference startup scenarios for ITER specify breakdown at the outer limiter with shape-controlled l_i variations maintained until the current flattop is reached. This evolution differs from startup prescriptions for existing tokamaks. Corsica simulations of the ITER current ramp indicate that this prescribed l_i may be difficult to achieve. We are validating these scenarios using Corsica to simulate ITER similarity experiments conducted on DIII-D. With these validated results, we explore possible alternatives to the current ramp-up that maintain stability and possibility for higher safety factor, $q_{min}>1$, more conducive to advance tokamak and hybrid modes. These simulations use the Corsica free-boundary evolution with transport to assess characteristics of the shaped evolution and vertical stability. Supported by the US DOE under W-7405-ENG-48, De-FC02-04ER54698, DE-AC05-00OR22725, and DE-FG02-04ER54758.

JP8.00100 Feasibility Studies of Off-Axis Neutral Beam Current Drive in DIII-D, M. MURAKAMI, J.M. PARK, ORNL, T.C. LUCE, H.E. ST. JOHN, M.R. WADE, General Atomics, T.A. CASPER, LLNL — The objective of off-axis neutral beam (NB) current drive (CD) is to supplement the off-axis electron cyclotron current drive for development of steady state, advanced tokamak scenarios. A modification being considered is to tilt the present neutral beam lines (BL) by raising the source end of the BL by ≈ 1.5 m. The driven current is calculated using the TRANSP and ONETWO/Nubeam Monte-Carlo codes taking into account finite orbit effects. When the beam is injected in the same direction as the toroidal field, a wide but localized off-axis CD ($\approx$40 kA/MW at $\rho = 0.5$ with FWHM of 0.45) is calculated. The normalized CD efficiency ($\varsigma = 0.22$) is comparable or somewhat better than electron cyclotron current drive. Sensitivities to fast ion diffusion and the use of the off-axis CD for scenarios with high steady-state performance in DIII-D will be discussed. Supported by the US DOE under DE-AC05-00OR22725, DE-FC02-04ER54698, and W-7405-ENG-48.

JP8.00101 Modulated Electron Cyclotron Current Drive for Control of the m/n=2/1 Neoclassical Tearing Mode in DIII-D, A.S. WELANDER, General Atomics, AND THE DIII-D NTM CONTROL FOR ITER THRUST TEAM — The m/n=2/1 neoclassical tearing mode (NTM) is a helical island structure at q=2 in the magnetic field of a high beta tokamak plasma that can degrade confinement and lead to disruption. The DIII-D control system has previously suppressed this NTM by driving continuous-wave (cw) current at q=2 using localized electron cyclotron current drive (ECCD). The control system has now been upgraded to modulate the ECCD so that current is driven only when the island passes by the deposition point. This modulation is expected to increase the effectiveness of the ECCD, in particular when the deposition region is broad relative to the island width, as will be the case in ITER. Experiments using modulated ECCD with a broad profile relative to the island width have been performed in DIII-D to control the 2/1 NTM. Results of these experiments will be presented. Supported by the US DOE under DE-FC02-04ER54698.

JP8.00106 Experimental comparison of fast wave absorption on fast ions at fourth and sixth harmonics, P.I. PINSKER, C.C. PETTY, General Atomics, W.W. HEIDBRINK, UC-Irvine, F.W. BAITY, ORNL, M. PORKOLAB, MIT — In recent DIII-D experiments, we have compared the absorption of fast waves (FWs) on injected deuterium beams at the fourth and sixth deuterium cyclotron harmonics. Direct electron absorption also plays an important part in the core absorption. Up to 2 MW of FW power at 90 MHz is compared with a similar level of 60 MHz power in low-density L-mode discharges at 2 T with 1–2 MW of deuterium beam injection at 80 keV. Changes in the neutron rate and in the central sawtooth behavior are correlated with the observed acceleration of the beam ions by the rf as measured by the D_α charge exchange recombination diagnostic. Results obtained with hydrogen beams in which second and third harmonic absorption at 60 MHz and 90 MHz are compared will be presented. Lower global absorption efficiency observed for higher cyclotron harmonics in this multiple-pass absorption regime is attributed to the effect of an edge loss that competes with the core absorption mechanisms. Supported by the US DOE under DE-FC02-04ER54698, SC-G903402, DE-AC05-00OR22725, and DE-FG02-90ER54084.

JP8.00109 **Theoretical Progress on Runaway Electron Suppression by Massive Gas Injection**, P.B. PARKS, W. WU, General Atomics, E.M. HOLLMANN, UCSD — Development of techniques to mitigate the severity of emergency plasma termination/plasma disruptions is deemed one of the highest priorities for ITER. The current method of mitigation by massive gas injection (MGI) is not fully understood; whether MGI can achieve sufficient density to avoid avalanche runaway electron formation in the high toroidal electric field E_ϕ is presently uncertain. It will be shown why direct penetration of broad gas jets cannot happen: ablation pressure drag (or magnetic pressure imbalance) exerted over the frontal surface of the jet is too strong for usual jets. Evidence on DIII-D is that MHD processes, occurring predominately during the short thermal quench TQ phase, cause inward diffusion of gas jet ions "stuck" at the plasma edge. To explore this process we have developed a 1-D large-aspect-ratio circular flux surface code for the evolution of E_ϕ with radiation and transport cooling. We use resistive wall boundary conditions, and a 2D axisymmetric CFD code describes the heavily-fueled vacuum region and plasma boundary conditions. Supported by US DOE under DE-FG03-95ER54309, DE-FC02-04ER54698, and DE-FG02-04ER54758.

JP8.00110 **Experiments With a 6-Valve Array for Massive Gas Injection for Disruption Mitigation in DIII-D**, T.C. JERNIGAN, L.R. BAYLOR, S.K. COMBS, ORNL, E.M. HOLLMANN, J.A. BOEDO, R.A. MOYER, D.L. RUDAKOV, J.H. YU, UCSD, T.E. EVANS, D.A. HUMPHREYS, P.B. PARKS, E.J. STRAIT, J.C. WESLEY, M.A. VAN ZEELAND, W.P. WEST, GA, D.G. WHYTE, MIT, M. BAKHTIARI, FIT — A 6-valve array was installed on the DIII-D to test massive gas injection for suppression of runaway electrons during disruptions. Previous experiments were limited by the peak flow rate from a single valve. Initial experiments show somewhat improved electron assimilation before the core thermal quench (TQ). Peak core mixing efficiencies of impurities injected into the vacuum vessel through the TQ are ~10%-40%. Tests using up to 5 valves were done in H_2, He, and 98% H_2-2% Ar. These experiments injected as much gas before the TQ as previously obtained during the entire TQ/I_p decay. They also showed the importance of maintaining the gas flow during the I_p decay to maintain the density. Densities of up to 2×10^{21} m^{-3} were obtained (~10% of the Rosenbluth density for runaway suppression), but it was still increasing with added valves. Supported by the US DOE under DE-AC05-00OR22725, DE-FG02-04ER54758, DE-FC02-04ER54698, and DE-FG02-04ER54762.

JP8.00112 **Experiments Toward Understanding Impurity Assimilation During Massive Gas Injection for Disruption Mitigation in DIII-D**, E.M. HOLLMANN, J.A. BOEDO, R.A. MOYER, D.L. RUDAKOV, J.H. YU, UCSD, T.C. JERNIGAN, ORNL, T.E. EVANS, D.A. HUMPHREYS, P.B. PARKS, E.J. STRAIT, J.C. WESLEY, W.P. WEST, GA, M. GROTH, H. SCOTT, LLNL, D.G. WHYTE, MIT — Impurity assimilation following massive gas injection (MGI) is desirable for collisional suppression of runaway electrons (RE). Experiments on the DIII-D tokamak have shown that impurity ions created at the plasma edge by MGI initially mix inward quite slowly toward the plasma core. When the associated cold front reaches the q=2 rational surface, impurity mixing is accelerated due to destabilization of low-order tearing modes, leading to the thermal quench (TQ). Average core mixing efficiencies of impurities injected into the vacuum vessel up through the TQ are of order 10%. Typically, RE suppression ratios $\gamma_{crit} = E_{crit}/E_\parallel \approx 0.01$ are obtained using argon. Better suppression ratios $\gamma_{crit} \approx 0.06$ are obtained with low-Z (H_2 or He) injection and firing five MGI valves simultaneously. Supported by the US DOE under DE-FG02-07ER54917, DE-AC05-00OR22725, DE-FG02-04ER54758, DE-FC02-04ER54698, W-7405-ENG-48, DEFG03-95ER54309, and DE-FG02-04ER54762.

Tuesday, November 13, 2007 7:30PM - 9:30PM
Town Meeting on ITER Design Review
Rosen Centre Hotel Junior Ballroom

A review of the ITER design has been carried out by eight international working groups this year, which will culminate in a new baseline design. The design review process, the U.S. involvement in it, and the status of design changes will be described. The speakers will be:

* Dr. Guenter Janeschitz, Director of the Nuclear Fusion Program at Forschungszentrum Karlsruhe, who has served as the ITER Design Review Coordinator will speak on "Status of the ITER Baseline Design after the Design Review".

* Dr. Richard Hawryluk, Deputy Director of Princeton Plasma Physics Laboratory, who served as a U.S. member of Working Group 1 on Design Requirements and Physics Objectives for the ITER Design Review will speak on "BPO Inputs to ITER Design Review Studies on In-Vessel Components and Discharge Evolution".

* Dr. Ronald Stambaugh, Vice-President, Magnetic Fusion Energy Program, General Atomics, who also served as a US member of Working Group 1 on Design Requirements and Physics Objectives for the ITER Design Review will speak on "BPO Input to the ITER Design Review for In-vessel Components and Plasma Control".

This Town Meeting is sponsored by the U.S. Burning Plasma Organization.

Wednesday, Nov 14 2007 9:30AM – 12:30PM
Session NP8 Poster Session V: MHD and Waves; Inertial Confinement Fusion II and HEDP Diagnostics; C-Mod Tokamak; ITER and Magnetic Fusion Development
Rosen Centre Hotel Grand Ballroom

NP8.00014 Spectral Gap of Shear Alfvén Waves in a Periodic Array of Magnetic Mirrors, ROGER MCWILLIAMS, YANG ZHANG, WILLIAM HEIDBRINK, HEINZ BOEHMER, UC Irvine, GUANGYE CHEN, BORIS BREIZMAN, UT Austin, STEPHEN VINCENA, TROY CARTER, DAVID LENEMAN, WALTER GEKELMAN, BRIAN BRUGMAN, UCLA, UC IRVINE TEAM, UT AUSTIN COLLABORATION, UCLA COLLABORATION — A multiple magnetic mirror array is formed at the LArge Plasma Device (LAPD), to study axial periodicity-influenced Alfvén spectra. Shear Alfvén Waves (SAW) are launched by antennas inserted in the LAPD plasma. From radial wave field scans with B-dot probes at many axial locations, SAW standing-wave formation and wave refraction in mirror cell(s) are observed. Alfvén wave spectral gaps and continua are formed similar to wave propagation in other periodic media due to the Bragg effect. The width of the propagation gap scales with the modulation amplitude according to the solutions of Mathieu's equation. A 2-D finite-difference code modeling SAW in a mirror array configuration shows similar spectral features. Machine end-reflection conditions and damping mechanisms including electron-ion Coulomb collision and electron Landau damping are important for simulation. Work supported by DOE DE-FG02-03ER54720.

NP8.00027 Modified Budden Problem Associated with an Energetic-Particle Population, A.N. KAUFMAN, LBNL & UCB, A.J. BRIZARD, SMC, E.R. TRACY, W & M — Our main motivation is to investigate what new effects are introduced in standard heating and/or current-drive scenarios when a non-Maxwellian population of energetic particles (e.g., fusion alphas) is taken into account. In particular, we investigate how energy from a wave supported by a population of energetic particles (e.g., Bernstein wave) can be transferred to a bulk-ion wave through the itermediary of a magnetosonic wave. For this purpose, a three-wave Budden model with two resonance layers is constructed that allows recirculation of energy fluxes around a rectangle in ray phase space. The transmission, reflection, and conversion coefficients for this extended Budden problem are calculated by ray phase- space methods and the modular-eikonal approach [1,2]. The analytical and numerical results show that all of the connection coefficients exhibit interference effects that depend on an interference phase that can be calculated from the coupling constants at each conversion point and the area enclosed by the rectangle. When one of the three waves is a negative-energy wave supported by an inverted energetic-particle population, the magnitude of the conversion coefficients can exceed 100%. Such amplification effects may provide a new form of alpha-channeling. [1] Y. M. Liang, et al., Phys. Lett. A 193, 82 (1994). [2] A. J. Brizard, et al., Phys. Plasmas 5, 45 (1998).

NP8.00067 Simulations and Experiments on Modifying the q-profile for Advanced Tokamak Discharges on Alcator C-Mod, C. KESSEL, S. SCOTT, R. WILSON, PPPL, A. HUBBARD, P. BONOLI, J-S. KO, Y. LIN, R. PARKER, A. SCHMIDT, D. TERRY, G. WALLACE, S. WOLFE, S. WUKITCH, MIT PSFC — As part of the advanced tokamak scenario development on Alcator C-Mod, time-dependent simulations using the Tokamak Simulation Code (TSC) and experiments are examining the impact of ion cyclotron radio frequency (ICRF) heating and Lower Hybrid (LH) heating and current drive on plasma evolution. Here the ICRF heating is obtained by using the hydrogen minority scheme at 80 MHz with BT of 5.4 T. The LH utilizes 4.6 GHz and a phasing of 90 degrees co-CD. Slower plasma current ramps, earlier diverting with heating, H-mode transition, and either ICRF or LH heating, as well as both together, are examined. The sawtooth onset, li, surface voltage, motional stark effect (MSE), and profile data are being used to categorize the impact and constrain the simulations where possible. Experiments have shown that LH powers less than 1/4 of the injected ICRF power can significantly delay the sawtooth onset when injected during rampup. While on the other hand, the ICRF power is found to be critical for accessing the H-mode. Supported by US DOE Contract No. DE-AC02-76CH03073 and DE-FC02-99ER54512.

NP8.00068 Current Profile Modification By Lower Hybrid Waves in Alcator C-Mod, R.R. PARKER, P.T. BONOLI, A.E. HUBBARD, J. KO, M. PORKOLAB, A.E. SCHMIDT, D.E. TERRY, G.M. WALLACE, S.M. WOLFE, J.C. WRIGHT, MIT PSFC, S.D. SCOTT, J.R. WILSON, PPPL — Driving current off-axis is a prerequisite for realizing steady-state, high-performance Advanced Tokamak (AT) regimes. Lower Hybrid Current Drive (LHCD) is well suited for this purpose since the driven current is typically deposited beyond r/a = 0.5. An important step toward the goal of forming AT regimes with LHCD in Alcator C-Mod is validation of ray-tracing and full-wave codes regarding the location of the LH driven current. In LH experiments on C-Mod, bremsstrahlung produced by fast electrons carrying the RF-induced current indicates that the current is driven off-axis at a location determined by the parallel index of refraction. This is in qualitative agreement with expectation and is supported by indirect evidence such as decreased li, sawtooth stabilization, and changes in q(r) as inferred from MSE. The results will be compared with the predictions of ray-tracing (GENRAY) and full-wave codes (TORIC) coupled with Fokker-Planck codes that follow the self-consistent evolution of f(v). Supported by USDoE awards: DE-FC02-99ER54512 and DE-AC02-76CH03073.

NP8.00083 Design and operation of a novel divertor cryopumping system in Alcator C-Mod, B. LABOMBARD, B. BECK, J. BOSCO, R. CHILDS, D. GWINN, J. IRBY, R. LECCACORVI, S. MARAZITA, N. MUCIC, S. PIERSON, Y. ROKHMAN, P. TITUS, R. VIEIRA, J. ZAKS, A. ZHUKOVSKY, MIT Plasma Science and Fusion Center — C-Mod's recently installed upper-divertor cryopump is unique among the world's tokamaks, employing an array of gas-pumping slots that penetrate the upper divertor target. This geometry enables the use of a single toroidal loop of liquid helium, operating in an efficient heat transfer regime with low or no helium flow. A system pumping speed of 9,600 l/sec for D_2 gas has been achieved, matching that of a full-scale prototype system. Neutral pressures in the pumping slots during upper-null plasmas (USN) are found to meet or exceed pressures in the lower divertor's private flux region during lower-null (LSN) – evidence that the pumping-slot geometry is performing as intended. Very high steady-state pumping throughputs (exceeding ~140 torr-l/s) have been demonstrated in USN. Reliable and efficient operation of the pump has been established, synchronized with the C-Mod shot cycle and consuming 60 to 90 liters of liquid helium during a full day of operation. Supported by U.S. DOE Agreement DE-FC02-99ER54512.

NP8.00087 Effect of Secondary Beam Neutrals on MSE: Theory, S. SCOTT, PPPL, J. KO, I. HUTCHINSON, MIT-PSFC, H. YUH, Nova Photonics — A standard calibration technique for Motional Stark Effect (MSE) diagnostics is to compare the polarization direction of Doppler-shifted Hα emission from a diagnostic neutral beam (DNB) that is fired into a gas-filled torus to the pitch angle inferred from known toroidal and vertical fields. However, the polarization direction of Hα emission from 'secondary' beam neutrals that ionize, gyrate about field lines, and then charge exchange a second time differs from the polarization direction of the 'primary' beam neutrals and thus confuses the calibration results. We compute the ratio of secondary-to-primary Hα emission, I_s/I_p, as a function of torus pressure for 50 keV hydrogen atoms in Alcator C-Mod. For helium gas, I_s/I_p is about unity at P=1 mTorr for the DNB in its recently re-oriented configuration (7° from perpendicular). The effect on the MSE calibration of Hα emission from these secondary beam neutrals is calculated by adding the Stokes vectors for all secondary-beam gyro angles whose Doppler shift lies within the MSE filter passband. The computed calibration error increases linearly with torus pressure and has distinct dependencies on MSE viewing geometry and pitch angle which are in qualitative agreement with recent measurements. Work supported by USDoE awards DE-AC02-76CH03073* and **DE-FC02-99ER54512.

NP8.00088 Design of a new X-mode edge reflectometer for Alcator C-mod, CORNWALL LAU, MIT Plasma Science and Fusion Center, GREG HANSON, JOHN WILGEN, Oak Ridge National Laboratory, YIJUN LIN, STEVE WUKITCH, MIT Plasma Science and Fusion Center — The study of antenna-plasma interactions during RF heating and current drive often requires high temporal and spatial resolution density profiles of the SOL in front of the ICRF antenna. A new swept-frequency X-mode reflectometer is being built for Alcator C-mod to measure the edge density profiles in front of the future E port antenna. Due to the presence of strong ICRF heating and large density fluctuations, density profile measurements are difficult. This reflectometer is thus designed to use both differential-phase and full-phase reflectometry techniques to allow for the best results to be obtained. The system is planned to operate between 100 and 145 GHz at sweep rates from 10 μs to 1 ms and will cover a density range of approximately 10^{16} to 10^{20} cm^{-3} at 5-5.4 T. Design of this new reflectometer and initial results from modeling and testing will be presented. Supported by DE-FC02-99ER54512 and DE-AC05-00OR22725.

NP8.00093 Kalman Filter for the Real Time Estimation of the Vertical Position of C-Mod Plasmas, M. FERRARA, I. HUTCHINSON, S. WOLFE, J. STILLERMAN, T. FREDIAN, MIT PSFC — A Kalman filter has been implemented for the real-time estimation of the vertical position of C-Mod plasmas. The simulator Alcasim, which reproduces the full evolution of a discharge, is used to synthesize the filter matrices at a time point. The linear model is then employed in the filter for the full duration of the flattop and for different target plasmas, in order to test for robustness. The filter has been extensively tested in linear and full Alcasim simulations. The performance in terms of noise rejection and signal distortion is evaluated in comparison with standard filtering such as lowpass and bandpass. Results show excellent signal tracking and noise rejection. For real-time implementation, computation speed is also a requirement, therefore issues such as off-line training of the filter and linear model reduction are investigated. The experimental test of the filter in the C-Mod fast vertical control loop is expected shortly. This could demonstrate a possible solution to the problem of control degradation and AC losses expected on ITER because of measurement noise. USDoE award DE-FC02-99ER54512.

NP8.00097 Diagnostics to Study Flow of Dust Particles in Scrape-Off Layer of Alcator C-Mod Plasmas, AARON BADER, ROBERT GRANETZ, BRIAN LABOMBARD, JAMES TERRY, MIT PSFC — Dust transport and migration is not well understood in tokamaks. Furthermore, current numerical codes (DUSTT) have not been benchmarked with experiments. Interest in dust has increased over recent years as it may be a significant issue in machines with high duty cycles (ITER, DEMO) due to safety concerns. Measuring dust particle trajectories in the plasma can also give added information on Scrape-Off Layer (SOL) flows, since an important force on dust flow is a plasma drag force. In order to study dust particle trajectories in the SOL for different plasma densities and topologies, we have designed and installed a dust injector which injects Boron dust particles into the divertor region. The particles are viewed with a video camera. This provides us with a 2-D projection of the particle trajectories. For full 3-D trajectories we would need to install a second viewing camera. Initial data and results will be presented along with the successes and shortcomings of the diagnostic and future improvements. This work is supported by USDoE award DE-FC02-99ER54512.

NP8.00098 **Stationary ELM-free H-mode on TCV**, L. PORTE, S. ALBERTI, E. ASP, A. BORTOLON, A. KARPUSHOV, Y. MARTIN, O. SAUTER, Ecole Polytechnique Federale de Lausanne (EPFL), Centre de Recherches en Physique de Plasmas, Association EURATOM Confédération Suisse — By heating an ohmic ELMy H-mode target using vertically launched 3rd harmonic X-mode ECRH (X3), it was possible to obtain coupled power up to ≈1.3MW which was much greater than the ≈ These discharges often transited to an ELM-free H-mode regime with constant electron density and stored energy in which the stored energy and toroidal beta both doubled. The maximum, achieved toroidal beta was 2.5% while the ideal beta-limit for these discharges was 3.5%. The recycling light level was high compared to the baseline ohmic H-mode level and the fluctuations in the recycling light level were correlated with core MHD. The energy confinement time was high, $H_{IPB98\,(y,2)} \approx 1.7$, and was limited by core MHD. Measurements of ion temperature profiles and rotation velocity showed that the mid-radius ion temperature increased from 500eV to 1keV while the plasma rotation increased also from 5kms^{-1} to 50kms^{-1}. An overview of these experiments will be presented. This work partially supported by the Fonds National Suisse de la Recherche Scientifique.

NP8.00106 **ITER Low-Field-Side-Reflectometer Conceptual Design Considerations**, W.A. PEEBLES, P-A. GOURDAIN, T.L. RHODES, L. ZENG, S. KUBOTA, G.WANG, E.J. DOYLE, UCLA – The ITER environment will be extremely harsh with heat loads and neutron flux levels reaching unprecedented levels. Ensuring the availability, reliability and accuracy of profile monitoring capabilities in ITER represents a major challenge. In contrast to optical-based diagnostics millimeter-wave systems are well-suited to this harsh environment. The first detailed U.S. assessment of the low-field-side reflectometer system is presented. Relativistic effects occur at high temperatures introducing a number of measurement challenges. Large changes in the reflectometry cutoff location occur due to relativistic mass correction, which leads to density profile measurement in ITER becoming dependent on knowledge of the local electron temperature. Furthermore, cutoff contours can become hollow and electron cyclotron absorption increases. These effects restrict core access and significantly modify wave propagation in the core plasma. The impact of these issues on reflectometry measurement capabilities is described and potential solutions discussed. U.S. Department of Energy, PPPL/USIPO Subcontract #S006786-F.

NP8.00107 **Study of Doppler Backscattering Measurements For ITER**, T.L. RHODES, S. KUBOTA, W.A. PEEBLES, L. ZENG, E.J. DOYLE, AND G. WANG, UCLA – Millimeter-wave based diagnostic systems are well suited to the harsh environment expected in ITER and other future burning plasmas. One such technique, Doppler reflectometry, has been proposed for plasma rotation measurements on ITER. In this technique radiation is injected at an angle with respect to the plasma edge and the Doppler shift of the density fluctuations monitored. This shift depends upon both the background ExB velocity as well as the intrinsic propagation velocity of the fluctuations. The physics of Doppler backscattering and its specific application to ITER are studied using full wave 2D simulations for ITER scenarios. Near the cutoff layer a long wavelength electric field pattern is formed roughly parallel to the flux surface. It is this field pattern that interacts strongly with the density fluctuations propagating in the poloidal direction, i.e. within the flux surface. Data from the DIII-D tokamak as well as the limitations and potential of this method for ITER will be presented and discussed. Supported by the US DOE under PPPL/USIPO Subcontract S006786-F.

NP8.00108 **Initial Design of Visible/IR Camera Optics for Upper Ports of ITER,** C.J. LASNIER, L.G. SEPPALA, K. MORRIS, M.E. FENSTERMACHER, M. GROTH, Lawrence Livermore National Laboratory – We show an initial optical design for the visible/IR camera systems that are a US responsibility for 6 of the ITER upper ports. Optics are enclosed in a tube with a entrance aperture through the blanket shield module. An aspheric collection mirror sends light to a flat mirror that redirects the beam along the port tube. Dogleg mirrors provide a jog in the beam, allowing for neutron shielding. The beam is spatially split into visible and IR beams inside the port flange, for separate vacuum windows. Spatial resolution is diffraction-limited by the aperture, which in turn depends on the size of the optics allowed in the port plug. For a view of the entire outer divertor plate with no intermediate focusing optics in the port tube, the spatial resolution is poorer than the specified 3mm. We show the resolution advantages of reducing the field of view and of adding a lens in the port plug. Work performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48. Work supported by the US ITER Project Office.

NP8.00109 **System Design of the MSE Diagnostic for ITER**, M.A. MAKOWSKI, S.L. ALLEN, M. GU, C.T. HOLCOMB, S. LERNER, K. MORRIS, N. WONG, Lawrence Livermore National Laboratory, R. CHIPMAN, University of Arizona — System designs for both the core and edge motional Stark effect (MSE) diagnostics for ITER have been developed and continue to be refined. An integrated system model has been developed that includes the emission physics and full optical properties of the four mirror relay system. Emphasis has been placed on minimizing the polarization aberrations of the optical relay system. A mechanical design has also been developed that can be coupled to a neutronics code for rapid evaluation of the shielding efficacy as alternative designs are examined. As part of the design program, candidate mirror materials are being characterized and then incorporated into the optics model to evaluate their impact on system performance. An overview of the system will be presented, together with various aspects of the emission model and optical and mechanical designs. Supported by the US DOE under W-7405-ENG-48.

NP8.00110 **Evaluation of a DNB for ITER-Based on Common Long-Pulse Positive Ion Source Technology**, D.M. THOMAS, R.W. CALLIS, R.M. HONG, H.K. CHIU, General Atomics, M. VON HELLERMANN, FOM Inst. for Plasma Physics — The use of a diagnostic neutral beam (DNB) is critical for the ITER diagnostic mission in order to provide radially resolved profiles of helium ash density as well as ion temperature, density, and rotation profiles. However, the estimated performance requirements for a suitable beam have yet to be demonstrated for either negative or positive ion source technology. In this paper we re-examine the suitability of existing common long pulse source (CLPS) technology, as exemplified in the DIII-D and TFTR programs, to provide a positive-ion-based DNB that will satisfy the ITER mission requirements with high reliability and ease of modulation. Straightforward modifications of the existing ion sources are expected to provide greater than 50 A of full energy hydrogen atoms at 100 keV, with a peak current density at the shield aperture approaching 200 A/m^2. Estimated S/N for BES and CXRS measurements for specific ITER operating scenarios will also be presented. Supported by the US DOE under DE-FC02-04ER54698.

NP8.00114 **170 GHz ITER ECH Transmission Line Estimated Losses and Testing**, M.A. SHAPIRO, S.T. HAN, J.R. SIRIGIRI, D. TAX, R.J. TEMKIN, P.P. WOSKOV, MIT PSFC, T.S. BIGELOW, D.A. RASMUSSEN, ORNL — The US will build 24 Transmission Lines (TL) connecting the 170 GHz gyrotrons to the ITER tokamak. Losses in the 63.5 mm diameter corrugated waveguide are estimated using an approximate analytical theory as 11% for a TL length of about 100 m. Experimental demonstration of such low loss transmission is a challenge. The results of estimation can be verified through precise measurements and advanced simulations. A set of 170 GHz corrugated waveguide TL components built by General Atomics is under test at MIT. High precision measurement techniques include a vector network analyzer and a radiometer. The miter bends are tested as critical TL components, since they are responsible for the largest amount of mode conversion and loss. The testing results are compared with advanced simulations using the HFSS code (Ansoft Corp.). Another critical issue is additional loss due to thermal or mechanical distortion of the miter bend mirror and the waveguide sections during 1 MW CW power transmission. The critical issues have been revealed in high power CW test of the 170 GHz TL using the 1 MW 170 GHz gyrotron at JAEA, Japan. The US is planning a high power test stand for testing the ITER TL. Advanced thermo-mechanical simulations and HFSS electromagnetic simulations will be conducted to explain the experimental results.

NP8.00122 **Crossing the Next Frontier**, R. GOLDSTON, J. MENARD, PPPL, J. BROOKS, ANL, R. DOERNER, UCSD, D. GATES, G.-Y. FU, N. GORELENKOV, R. KAITA, S. KAYE, G. KRAMER, H. KUGEL, R. MAJESKI, M. ONO, C. SKINNER, J. STRACHAN, PPPL, J. HARRIS, R. MAINGI, ORNL, M. KOTSCHENREUTHER, S. MAHAJAN, P. VALANJU, U Texas, R. NYGREN, M. ULRICKSON, SNL, D. RUZIC, U Ill, S. SABBAGH, Columbia, V. SOUKHANOVSKII, LLNL — The plasma-material interface is the next frontier in fusion science. ITER's approaches to heat flux and tritium retention do not extrapolate to Demo. Defining questions at this frontier include: Can extremely high radiated-power fraction be consistent with high confinement and low Z_{eff}? Can magnetic flux expansion or edge ergodization reduce heat loads sufficiently? Can tungsten survive with acceptable core radiation and tritium retention? Can liquid metals more effectively handle high heat flux, off-normal loads and tritium exhaust? Answers must be integrated with high-performance, fully steady state plasma operation, avoiding ELMs and eliminating disruptions. The vehicle to cross this frontier is a high-power-density plasma with long pulses, excellent diagnostic access, flexible first wall, divertor, heating, current drive and plasma control systems, extensive deuterium and trace tritium operation, and the ability to test a range of plasma-facing materials at reactor-relevant temperature. This work supported in part by U.S. DOE Contract # DE-AC02-76CH03073.

NP8.00123 **Fusion Development Facility – Mission and Overview** R.D. STAMBAUGH, V.S. CHAN, AND C.P.C. WONG, GA – A Fusion Development Facility (FDF) is proposed to make possible a fusion demonstration power plant (DEMO) as the next step after ITER. To make possible a DEMO of the ARIES-AT type, the mission of the FDF should be to carry forward Advanced Tokamak physics and enable development of fusion energy applications. FDF should demonstrate advanced physics operation of a tokamak in steady-state with burn, producing 100-250 MW fusion power with modest energy gain (Q<5) in a modest sized device. Full noninductive, high bootstrap operation will enable continuous operation for periods up to two weeks. FDF must further develop all elements of AT physics for an advanced performance DEMO. With neutron flux at the outboard midplane of 1-2 MW/m^2 and a goal of a duty factor of 0.3, FDF can produce fluences of 3-6 MW-yr/m^2 in ten years of operation. FDF will have a goal of producing its own tritium and building a supply to start up DEMO. The development of blankets suitable for tritium, electricity, and hydrogen production will be done in port modules. FDF, ITER, IFMIF, and other AT devices will provide the basis for a fusion DEMO power plant of the ARIES-AT type. Supported by the GA IR&D funding.

NP8.00124 **Physics-Based Performance Projections for Fusion Development Facility**, V.S. CHAN, R.D. STAMBAUGH, M.S. CHU, R.K. FISHER, C.M. GREENFIELD, D.A. HUMPHREYS, L.L. LAO, J.A. LEUER, T.W. PETRIE, R. PRATER, G.M. STAEBLER, H.E. ST JOHN, P.B. SNYDER, A.D. TURNBULL, M.A. VAN ZEELAND, GA – The Fusion Development Facility (FDF) is a fusion application development facility based on advanced tokamak physics with copper magnets and tritium breeding capability. Theory based stability and transport studies are used to validate the performance projections from a system study based on simplified models. Ideal global and edge stability limits established by further optimization of high performance equilibria obtained in existing experiments indicate that the FDF power density and neutron flux requirements can be met with strong shaping and feedback control. Transport analysis using physics-based transport model with an edge condition consistent with the pedestal stability limit indicate the FDF confinement requirement can also be achieved. Interesting opportunities for study of alpha physics and challenges on first walls will be discussed. Supported by the GA IR&D funding.

Wednesday, November 14, 2007 9:30AM - 12:30PM
Session NM4 Mini-conference on Angular Momentum Transport in Laboratory and Nature III
Rosen Centre Hotel Salon 1/2

11:55AM NM4.00008 Edge Flows and Their Role in Intrinsic Rotation and the LH Transition, AHMET Y. AYDEMIR, Institute for Fusion Studies, The University of Texas at Austin — As we enter the era of next-step devices like ITER, where external momentum sources may prove insufficient, intrinsic mass flows are becoming increasingly relevant because of their importance in macroscopic stability and transport. There are flows in tokamaks driven purely by the toroidal geometry itself, making them an integral part of all tokamak plasmas. Related to the Pfirsch-Schlüter fluxes and dipolar in nature, these flows are localized to the edge region because of temperature gradients. Within the separatrix they are essentially cross-field, accompanied by parallel flows in the scrape-off layer (SOL) that tend to provide global mass conservation. In a symmetric system, the toroidal component of the SOL flows has no net angular momentum; however, asymmetries introduced, for example, by a single-null field geometry, results in a net momentum source at the edge. Coupled with an effective inward momentum transport mechanism (e.g., momentum pinch), this source can drive an intrinsic core rotation in the absence of any external momentum source. These flows also have the correct symmetry properties to account for the increased power threshold for the LH transition when the grad-B drift is in the “wrong” direction. Supported by the US Department of Energy.

Wednesday, November 14, 2007 2:00PM - 3:00PM
Session PT1 Tutorial: Scientific Challenges of Burning Plasmas
Rosen Centre Hotel Junior Ballroom

2:00PM PT1.00001 The Scientific Challenge of Burning Plasmas, JAMES W. VAN DAM, US Burning Plasma Organization — The next frontier for fusion is the study of burning plasmas. The ITER facility, to be operated as an international project, will push research efforts into this new regime. In this tutorial, we will first define a burning plasma and describe its distinguishing properties. One such feature is dominant selfheating (exothermic) by a large population of alpha particles, created from thermonuclear reactions. Fusion self-heating also leads to strongly nonlinear coupling of critical elements in MHD stability, transport, alpha particle losses, edge behavior, and burn dynamics. Also, burning plasmas require robust plasma-wall facing components and diagnostics that can withstand high heat and neutron wall loadings. Next, we will briefly review how previous experiments on JET and TFTR to attain break-even ($Q \leq 1$) have laid the foundation for taking the present step to ITER. Then, we will describe the various physics issues that need to be addressed for burning plasmas, both in preparation for ITER and also when operating at high fusion gain ($Q=5-10$). Examples of near-term research needs for ITER include the time-dependent study of start-up flexibility to determine whether suitable hybrid and steady-state plasmas can be produced; analysis of the possibility of integrated control of resistive wall modes, ELMs, neoclassical tearing modes, and error field effects; and loss of alpha particles and also beam and RF-heated fast ions due to magnetic field ripple and wave-particle resonances. In high-gain operation, the understanding of pressure limits for stability and turbulent transport for confinement (including pedestal and transport barrier dynamics) must be extended to large size (gyroradius much less than minor radius). Burning plasma operation will also require methods for dealing with tritium retention and replenishment. Other research opportunities will also be described. Work supported by OFES-USDOE.

Wednesday, November 14, 2007 2:00PM - 4:48PM
Session PO3 C-Mod Tokamak
Rosen Centre Hotel Salon 9/10

3:12PM PO3.00007 Hydrogenic Fuel Retention in Molybdenum, D.G. WHYTE, B. LIPSCHULTZ, J. IRBY, PSFC-MIT, G.M. WRIGHT, FOM-Rijnhuizen — High-Z refractory metals such as tungsten and molybdenum (Mo) are favored as plasma-facing components in burning plasma experiment to minimize hydrogenic (H) fuel retention, mainly due to their low H solubility (~1 appm). Fuel retention in Mo is studied and modeled in the Mo-tile Alcator C-Mod tokamak, and DIONISOS a new facility that features simultaneous plasma bombardment and real-time retention diagnosis. We find that high ion fluxes leads to D trap sites in the Mo; energy wells in which the fuel can reside at concentrations ~1%, i.e. much larger than the solubility. The tokamak environment leads to other unique characteristics such as temperature transients through heating and neutron bombardment that further increase retention. High temperature drives D traps and retention deeper into the Mo, but the sudden cooling of the material with removal of the plasma flux "freezes" the D deep in the Mo. This physical model recreates the C-Mod retention result, i.e. that a large fraction (~30%) of the fuelled D can be retained reproducibly over many shots, despite the absence of low-Z film growth. This retention mechanism is fundamentally different than co-deposition of D with carbon, which is observed to dominate D retention in most current tokamaks. The implications for burning plasmas with high neutron loads will be discussed.

Wednesday, November 14, 2007 2:00PM - 4:20PM
Session PM5 Mini-conference on the First Microns of the First Wall: Lithium Coatings and Surfaces
Rosen Centre Hotel Salon 11/12
See Appendix A

Thursday, November 15 2007 9:30 AM – 12:30 PM
Session TP8 Poster Session VII: Reconnection and Non-Neutral II; High Power Microwave and Laser Driven Sources; NSTX Spherical / General Torus; Simulation: HEDP/Plasma Accelerator/Space
Rosen Centre Hotel Grand Ballroom

TP8.00073 **Beam modulation effects on NSTX Ion Power Balance,** P.W. ROSS, D.A. GATES, S. MEDLEY, S.M. KAYE, R.E. BELL, B.P. LEBLANC, D.S. DARROW, R. WHITE, G. ZIMMER, Princeton Plasma Physics Lab, W.W. HEIDBRINK, M. PODESTA, D. LIU, U.C. Irvine, H. YUH, F.M. LEVINTON, Nova Photonics, NSTX TEAM — The coupling between the beam particles and the thermal ions is poorly understood. To examine the coupling, the beam power was modulated. The fast particles were then measured using a variety of diagnostics. The neutron rate from beam-target interactions shows the expected behavior, with the signal decreasing to a new steady state value in <10 ms. The Neutral Particle Analyzer (NPA) shows a presence of fast ions at various pitch angles, but not at others. The NPA measurement is compared to other fast ion diagnostics including the Fast Ion D Alpha (FIDA) diagnostic, the Solid State Neutral Particle Analyzer (SSNPA) and the Scintillator Fast Loss Ion Probe (SFLIP) diagnostic. Comparison is also made between measured NPA signals and TRANSP calculations. The ion and electron temperature were also measured and compared before and after the start of the modulation, and conclusions are drawn about the coupling between the beam and the plasma. This work supported by U.S. DOE Contract # DE-AC02-76CH03073.

TP8.00084 **Effect of Halo Neutrals on Neutral Particle Measurements**, D. LIU, W.W. HEIDBRINK, UC Irvine, S.S. MEDLEY, A.L. ROQUEMORE, PPPL, R.J. AKERS, UKAEA — The Neutral Particle Analyzer (NPA) diagnostics including the E||B type NPA and solid state NPA (ssNPA) array on the National Spherical Torus Experiment (NSTX) measure neutral production in charge exchange reactions between energetic ions and beam primary and halo neutrals. A Monte Carlo simulation code is developed to analyze the effect of primary neutrals and halo neutrals to the NPA flux temporal evolution and energy spectrum. The code is validated by comparing with the TRANSP-simulated NPA signals and an analytical halo diffusion model. The simulation results show that the density of halo neutrals around the beam footprint is comparable to that of primary neutrals. Charge exchange with halo neutrals contribute significantly to the neutral flux measured by NPA diagnostics for typical NSTX conditions. Effect of halo neutrals in quiet plasmas and discharges with beam modulation and vertical NPA scans will be presented. This work was supported by US DOE Grant DE-FG03-02ER54681.

TP8.00087 **Development of a fast-ion D-alpha diagnostic for NSTX,** MARIO PODESTA, W.W. HEIDBRINK, UC Irvine, CA 92697, R.E. BELL, W. SOLOMON, PPPL, Princeton, NJ 08543, V. SOUKHANOVSKII, LLNL, Livermore, CA 94550 — A Fast-Ion D-Alpha diagnostic based on active charge exchange recombination spectroscopy is being developed for NSTX. The first results from the 2007 run, obtained with a prototype setup, indicate that fast ion signals have been successfully detected. The signals show a clear time correlation with the neutron emission from beam-plasma reactions. During modulation of the injected neutral beam power, variations on the fast ion slowing down time-scale are observed. The signal amplitude from different spectral regions scales accordingly with the fast ion D_α spectrum. For the 2008 run, sixteen channels will cover the outboard poloidal cross-section with a resolution in space, time and energy of 5cm, 10ms and 10keV. In addition, three dedicated channels will monitor the signal from suprathermal ions on time-scales ~10us at different radii. Each channel includes two views inside the plasma, intercepting/missing the neutral beam for a direct subtraction of the background signal not associated with fast ions. Work supported by US DOE grant DE-FG02-06ER54867 and contract DE-AC02-76CH03073.

Thursday, November 15, 2007 9:30AM - 11:50AM
Session TM5 Mini-conference on the First Microns of the First Wall: Mixed Materials Issues
Rosen Centre Hotel Salon 11/12
See Appendix A

Thursday, November 15, 2007 2:00PM - 5:00PM
Session UI1 MHD
Rosen Centre Hotel Junior Ballroom

3:00PM UI1.00003 Extrapolating Neoclassical Tearing Mode Physics to ITER – Physics Basis and Experimental Comparison, RICHARD BUTTERY, EURATOM/UKAEA Fusion Association, Culham Science Centre, Oxfordshire, UK. — Neoclassical Tearing Modes (NTMs) represent one of the most serious concerns for baseline and hybrid scenario performance in ITER. Already on present devices they limit attainable β, degrading confinement and causing disruptions. The concern is increased for ITER where stabilising small island and rotation effects are likely to be reduced. In this paper we review the physics basis for NTM scalings, and compare to experimental behaviour, to deduce the key effects and impact on ITER prediction. The principal criteria for NTM onset is dictated by a competition between stabilising small island effects, and the drive from NTM-triggering MHD (eg. sawteeth). Typically the former arise from orbit and transport effects when island sizes are comparable to ion banana widths. This suggests a lowering of NTM β thresholds as ITER-like ρ^*_is are approached. In addition, reduced plasma rotation will increase NTM coupling to other instabilities and decrease stabilising effects due to wall and rotation shear. New studies on JET and DIII-D have highlighted this with falls of ~30% in both m/n=3/2 and 2/1 NTM β thresholds as momentum injection is removed. Indeed, a wide body of work confirms many aspects of the theory, particularly the expected small island effects and ρ^*_i scalings, while more detailed examinations, for example locally perturbing rotation with error fields, begin to distinguish particular physics mechanisms such as ion polarisation current effects. Thus consideration of the stabilising elements points to a lower metastability threshold for the NTM in ITER. Nevertheless, the triggering mechanisms provide grounds for optimism. For the most serious 2/1 NTM, onset in hybrid, and possibly baseline, scenario appears related to proximity to ideal β limits. Conversely, modes triggered by core MHD may be managed by proven control techniques for the core MHD itself. This work was jointly supported by the UK EPSRC and EURATOM under EFDA, and the US DOE under contract DE-FC02-04ER54698.

3:30PM UI1.00004 Advancing Tokamak Physics with the ITER Hybrid Scenario on DIII-D, P.A. POLITZER, General Atomics — Recent DIII-D experiments using hybrid scenario plasmas (hybrids) have furthered our understanding of transport and stability in high beta tokamaks, leading to the possibility of high fusion performance on ITER. The hybrid is a stationary, inductively driven, $q_0 \sim 1$ discharge with better confinement and stability than standard H-mode. Providing stationary, high beta conditions, the hybrid is an excellent configuration for study of tokamak plasma physics under conditions of interest to burning plasmas, such as low rotation, balanced T_e and T_i, shaping, and pedestal behavior. Compared to a standard H-mode, the hybrid has a broader current profile, reducing or eliminating the deleterious effects of sawteeth, and is less susceptible to m/n = 2/1 NTMs, allowing higher β operation. Our experiments have conclusively shown that the current profile is broadened by a relatively benign m/n = 3/2 NTM. Power balance in hybrids is dominated by electron heat conduction, but the observed electron thermal diffusivity is relatively small, and the ion thermal diffusivity is consistently at or close to the neoclassical value. Using the recent modification to the DIIID neutral beam configuration, we have been able to reduce the toroidal rotation velocity to a central Mach number <0.1, under stationary conditions. We find that confinement improves with increasing rotation. Gyrofluid simulations indicate that this is associated with the change in ExB flow shear. The width of the NTM island decreases as rotation and rotation shear are increased. However, the difference in the fusion performance parameter G ($=\beta_N \cdot H/q^2$) at low and high rotation is only 10%-30%. Thus, although rotation and rotation shear are important parameters for improving tokamak performance, good confinement and stability can be maintained even in their absence. Supported by US DOE under DE-FC02-04ER54698.

4:00PM UI1.00005 MHD simulations of disruption mitigation on DIII-D and Alcator C-Mod, V.A. IZZO, University of California, San Diego — The three potential threats posed by disruptions—halo currents, heat fluxes and runaway electrons—scale unfavorably from present tokamaks to ITER. Disruption mitigation experiments on several tokamaks have shown massive gas injection (MGI) to be an effective means of reducing poloidal halo current and heat flux. However, both theory and measurements support the conclusion the penetration of the neutral jet is weak. Thus the core thermal quench relies on MHD, both to mix impurities into the core, and to conduct heat to the impurity-dense edge. NIMROD simulations of C-Mod have shown that enhanced transport alone—due to large 1/1 and 2/1 modes triggered by edge cooling—can quench the core plasma [1]. These simulations show similarity to C-Mod temperature measurements [2], and the role of the 1/1 and 2/1 modes is supported by observations in DIII-D [3]. However, to determine the relative importance of thermal transport versus impurity mixing simulations that include both mechanisms are needed. An extension of the NIMROD code has been developed which includes both accurate atomic physics from the 0D KPRAD code and separate continuity equations for each species. C-Mod simulations for both helium and argon impurities are compared with earlier simulations and experimental data to assess the extent of impurity mixing and evaluate MGI as a mitigation technique for ITER. DIII-D simulations are carried out with different radial neutral fueling profiles to understand the thermal quench when impurity injection is more uniform, or centrally peaked, as would be the case for designer pellets or liquid jets. [1] V.A.

Izzo, Nucl. Fusion **46** (2006) 541. [2] R.S. Granetz, et al., Nucl. Fusion **46** (2006) 1001. [3] E.M. Hollmann, et al., Nucl. Fusion **45** (2005) 1046. Supported by US DOE under DE-FG03-95ER54309; In collaboration with D.G. Whyte, P.B. Parks, E.M. Hollmann, R.S. Granetz.

Thursday, November 15, 2007 2:00PM - 5:00PM
Session UP8 Poster Session VIII: Gyrokinetics, Two-Fluids and Assorted; DIII-D II; Turbulence and Transport; Plasma Sources, Sheaths, and Thrusters
Rosen Centre Hotel Grand Ballroom

UP8.00023 Overview of DIII-D Experimental Results and Program Plans, T.S. TAYLOR, General Atomics, DIII-D TEAM — The DIII-D research program is addressing urgent ITER R&D issues, improving Advanced Tokamak operation, and using an expanding set of control tools and diagnostics to better understand the physics of high performance tokamaks. Resistive wall mode experiments with counter beam injection addressed stability and feedback control in slowly rotating ITER-relevant plasmas, providing new data to compare with code predictions. ELM-control experiments using internal and external coils point to a physics basis for design of similar coils for ITER, and new disruption mitigation results show promise for suppression of runaway electrons. Steadily increasing ECH and fast wave power (2.4 MW ECH and 3.1 MW FW) provides the means to heat electrons to vary collisionality and T_e/T_i to study turbulent transport with improved diagnostics to measure a broad spectrum of density and temperature fluctuations, and will improve current profile control in AT plasmas. In the near future, we anticipate increased long-pulse ECH power to extend noninductive high bootstrap fraction AT performance; longer-term plans include 10 s operation at full field. Supported by the US DOE under DE-FC02-04ER54698.

UP8.00024 3D Structure and Dynamics of ELMs, T.E. EVANS, GA, J.G. WATKINS, SNL, I. JOSEPH, J.H. YU, UCSD, M. JAKUBOWSKI, MPI, O. SCHMITZ, FZ-Juelich — Understanding the global topology and dynamics of edge localized modes (ELMs) is essential for predicting transient loading on plasma facing surfaces. Fast visible line emission images taken during ELMs consistently show filament-like helical structures that expand radially outward from the pedestal while rotating toroidally. Fast infrared camera images show a rapidly evolving splitting and broadening of the divertor heat flux footprints that appear to be correlated with non-axisymmetric divertor currents. In single-null poloidally diverted configurations, these experimental signatures appear to be topologically consistent with a splitting of the separatrix into a set of invariant manifolds resulting in an object known as a homoclinic tangle in dynamical systems theory. Here, we describe a model in which helical currents flowing along this tangle amplify its size and toroidal phase. We compare predictions from this model to experimental measurements of the properties of filament-like structures measured with various DIII-D fast diagnostic systems. Supported by the US DOE under DE-FC02-04ER54698, DE-AC04-94AL85000, and DE-FG02-04ER54758.

UP8.00026 Effect of RMP on Edge Density Profiles and Fluctuations in DIII-D, L. ZENG, T.L. RHODES, E.J. DOYLE, G. WANG, W.A. PEEBLES, A.E. WHITE, UCLA, T.E. EVANS, General Atomics, R.A. MOYER, UCSD, M.E. FENSTERMACHER, LLNL — Resonant magnetic perturbation (RMP) has been used successfully to suppress Type-I edge localized modes (ELM) in DIII-D. In these ELM-suppressed operations, the detailed edge density profile and evolution of the fluctuations have been investigated in order to study the effect of RMP on edge transport. Utilizing a high-resolution profile reflectometer ($\Delta t=25$ μs, $\Delta r \geq 2$ mm), it is observed that with even parity n=3 RMP, pellet injection results in a larger increase in the scrape-off layer density and a smaller increase in the pedestal density gradient, as compared with no RMP. This result is consistent with the decay time of pellet-induced core density perturbation with RMP being shorter than without RMP, indicating an enhanced particle transport during the ELM-suppressed phase. The detailed density profile and fluctuation evolution will be presented for various RMP configurations, e.g. n=1, n=3, in both low and high collisionalities. Supported by the US DOE under DE-FG03-01ER54615, DE-FC02-04ER54698, DE-FG02-04ER54758, and W-7405-ENG-48.

UP8.00027 Particle Transport in RMP ELM Suppressed H-modes, R.A. MOYER, J.A. BOEDO, V.A. IZZO, I. JOSEPH, S. MORDIJCK, D.L. RUDAKOV, J.H. YU, UCSD, T.E. EVANS, N.H. BROOKS, T.H. OSBORNE, P. GOHIL, J.S. DEGRASSIE, A.W. LEONARD, GA, M.E. FENSTERMACHER, C.J. LASNIER, LLNL, J.G. WATKINS, SNL, T.C. JERNIGAN, ORNL, M. JAKUBOWSKI, MPI-Griefswald, O. SCHMITZ, FZJ, G. WANG, A.E. WHITE, L. ZENG, UCLA, G.R. MCKEE, U. Wisc.-Madison, C. ROST, J.R. DORRIS, MIT — Suppression of Type I ELMS with n=3 edge resonant magnetic perturbations (RMP) depends on reducing the pedestal pressure gradient below the peeling-ballooning mode stability limit. This pressure gradient reduction results from a reduction in pedestal particle density and effective particle confinement time τ_p*. Recent experimental results suggest that this τ_p* reduction arises from at least two mechanisms: increased ion-scale turbulence in the region 1>r/a>0.75, and improved coupling of the plasma to the pump due to strike point splitting. These mechanisms are observed to increase the density at the pump entrance, leading to improved pumping efficiency and lower τ_p*. Work supported by US DOE under DE-FG02-04ER54758, DE-FC02-04ER54698, W-7405-ENG-48, DE-AC04-94AL85000, DE-AC05-00OR22725, DEFG03-01ER54615, DE-FG02-89ER53296, and DE-FG02-04ER54235.

UP8.00029 Strike Point Splitting in RMP-ELM-free H-mode, I. JOSEPH, R.A. MOYER, UCSD, T.E. EVANS, M.J. SCHAFFER, W.P. WEST, GA, M.

JAKUBOWSKI, A.M. RUNOV, R. SCHNEIDER, MPI, S.V. KASILOV, Kharkov-IPT, O. SCHMITZ, FZ-Juelich, M.E. FENSTERMACHER, M. GROTH, C.J. LASNIER, LLNL, J.G. WATKINS, SNL — The E3D two-fluid code is used to model the effect of resonant magnetic perturbations on DIII-D thermal transport. The strike points are predicted to develop multiple striations determined by the invariant manifolds of the perturbed field, and the heat flux distribution is predicted to be well-correlated with the local connection length. Although filtered optical cameras observe striations in particle flux, the energy fluxes measured by infrared cameras and Langmuir probes do not appear to display significant splitting. This indicates that the perturbed field lines do not penetrate far inside the unperturbed separatrix. This is consistent with the fact that the predicted thermal transport is too large to match measured pedestal profiles. Both results may indicate that the rotational plasma response limits the stochastic field to a thin layer near the separatrix. Work supported by US DOE under DE-FG02-05ER54809, DE-FG02-04ER54758, DE-FC02-04ER54698, W-7405-ENG-48, and DE-AC04-94AL85000.

UP8.00030 Fast Imaging of ELM Structure and Dynamics in DIII-D, J.H. YU, J.A. BOEDO, E.M. HOLLMANN, R.A. MOYER, D.L. RUDAKOV, UCSD, P.B. SNYDER, GA — Fast-framing images of CIII and D emission in the low-field-side (LFS) plasma boundary of DIII-D show that ELMs are helical filamentary structures that rotate toroidally. The filaments propagate radially outward at v_r ~500 m/s during the nonlinear phase, and result in plasma-wall interactions that are poloidally localized within 15 cm of the midplane. The measured mean poloidal width of the filament is 3 cm, and the ELM toroidal mode number n ranges from 10 to 35. ELM structure and dynamics vary with plasma density, possibly because ELMs are driven by a peeling type of mode in low density plasmas and are driven by a coupled peeling-ballooning mode in high density. At high collisionality (υ_{ped}*=0.50), ELMs begin with an unstable filament or group of filaments at the LFS midplane region. Onset of the ELM-induced radiation in the divertor is delayed by as much as 0.8 ms compared to the midplane signals. In low collisionality ((υ_{ped}*=0.25) discharges, the midplane and divertor ELM signals appear simultaneously, possibly suggesting a more poloidally symmetric mode structure. Work supported by US DOE under DE-FG02-04ER54758 and DE-FC02-04ER54698.

UP8.00031 ELM Triggering From Deuterium Pellets Injected into DIII-D, L.R. BAYLOR, T.C. JERNIGAN, Oak Ridge National Laboratory, T.E. EVANS, P.B. PARKS, General Atomics, M.E. FENSTERMACHER, Lawrence Livermore National Laboratory, R.A. MOYER, University of California-San Diego — Deuterium fueling pellets have been injected into DIII-D plasmas from five different locations and under different plasma H-mode conditions. Edge localized modes (ELMs) have been triggered from pellets injected from all locations and under all the H-mode scenarios thus far explored. Pellets injected into plasmas with ELMs suppressed by a resonant magnetic perturbation are also observed to trigger one or more ELM like events. Experimental details of the pellet triggering of ELMs on DIII-D will be reviewed. In addition a pellet dropper has been installed on DIII-D for ELM pacing studies. Initial results from the slow 1mm pellets dropped into the edge plasma will be presented. Supported by US DOE under DE-AC05-00OR22725, DE-FG03-95ER54309, DE-FC02-04ER54698, W-7405-ENG-48, and DE-FG02-04ER54758.

UP8.00033 Target Plate Profiles During ELM Suppression Experiments on DIII-D, J.G. WATKINS, SNL, T.E. EVANS, C.J. MURPHY, GA, M.J. MARTIN, Cornell U., A. NELSON, U. of St Thomas, M. JAKUBOWSKI, KFZ-Juelich, I. JOSEPH, R.A. MOYER, UCSD, C.J. LASNIER, M.E. FENSTERMACHER, LLNL — Radial profiles of target plate plasma conditions during ELM suppressed conditions have been measured with the new DIII-D lower divertor Langmuir probe array. ELM suppression was accomplished using n=3 resonant magnetic perturbations [1]. Evidence of the n=3 mode structure of the perturbation can be seen most clearly in the V_f profile on the target plate. The spacing of the multiple peaks in the V_f profile is similar to predictions of the TRIP3D field line integration code. T_e values >100 eV and V_f values down to –150 V were measured. We observe resonant behavior of the target plate parameters near the q95 value for maximum magnetic perturbation. Heat flux from the Langmuir probe measurements will be compared with infrared cameras and thermocouples. The resulting sheath power transmission factor profile will be shown. [1] T.E. Evans, *et al.*, Phys. Rev. Lett. **92**, 235003 (2004). Supported by US DOE under DE-AC04-94AL85000, National Undergraduate Fusion Fellowship, DE-FC02-04ER54698, DE-FG02-04ER54758, and W-7405-ENG-48.

UP8.00034 Divertor Heat and Particle Fluxes During ELM Control Experiments, O. SCHMITZ, FZJ, M.W. JAKUBOWSKI, MPI, T.E. EVANS, M.J. SCHAFFER, W.P. WEST, GA, M.E. FENSTERMACHER, M. GROTH, C.J. LASNIER, LLNL, I. JOSEPH, R.A. MOYER, UCSD, B. UNTERBERG, H. FRERICHS, FZJ — In experiments exploring ELM suppression by resonant magnetic perturbation (RMP) as a technique for ITER, the manipulation of divertor heat and particle fluxes is of vital interest. To investigate these effects, a fast IR camera and CCD cameras equipped with D_α, CII or CIII interference filters were used during RMP ELM control experiments at DIII-D. In general, a splitting of the inner and outer divertor strike lines was observed. This is caused by splitting of the invariant separatrix manifolds that form magnetic footprints on the wall elements. Parallel particle and heat fluxes are transported along these field lines forming a characteristic pattern on the divertor target. The measured patterns are compared to magnetic footprints modeled with the TRIP3D code to identify the topology of the heat and particle flux channels. Based on that, the occurrence of complete ELM suppression is correlated to the measured and modeled target patterns. Supported by US DOE under DE-FC02-04ER54698, DE-FG02-04ER54758, and W-7405-ENG-48.

UP8.00040 Tritium Recovery From Carbon Co-deposits: *ex situ* Studies in Preparation for an *in situ* Thermal Oxidation Experiment in DIII-D, C. TSUI, J.W. DAVIS, A.A. HAASZ, B.W.N. FITZPATRICK, A.G. MCLEAN, P.C. STANGEBY, Y. MU, U. Toronto, S.L. ALLEN, LLNL, W.P. WEST, P.L. TAYLOR, K.L. HOLTROP, A.W. HYATT, R.L. BOIVIN, GA, K. UMSTADTER, UCSD — Tritium trapping in carbon co-deposits is potentially a major cause of T retention in ITER. A possible solution is “thermo-oxidation,” involving sub-atmospheric molecular O_2 at 250°-350° C. Ex situ lab tests (at U. Toronto) of graphite tiles removed from DIII-D have demonstrated the method in principle and generated a comprehensive database on removal rates. Ex situ tests were also performed for special components (e.g., diagnostic mirrors) used in DIII-D to assess potential damage. The next step is in situ demonstration in DIII-D to show that the D (as proxy for T) and C removed from the tiles actually leaves the vessel, that vessel components are not damaged, and that plasma operation can be recovered quickly. Lab results and implications for the in situ test are discussed. Work supported by the Natural Sciences and Engineering Research Council of Canada and by US DOE under W-7405-ENG-48, DE-FC02-04ER54698, and DE-FG02-04ER54578.

UP8.00042 Dust Particles Observed by Laser Scattering at DIII-D, B.D. BRAY, W.P. WEST, General Atomics, D.L. RUDAKOV, UCSD — Studies of dust particles observed by Rayleigh/Mie scattering of ND:YAG lasers during plasma operations at DIII-D show correlations with plasma configuration. Dust particles are primarily observed outside the last closed flux surface of the plasma. The mean particle density has been observed to be near 400 m^{-3} in both divertor scrape-off layer regions, corresponding to an upper or lower single-null configuration. The inferred particle size (~100 nm) indicates this represents a small carbon density relative to measured ionized carbon density in the plasma and consequently not believed to be a significant source of impurities. However, understanding the dust dynamics remains important because of its safety implications in future burning plasma reactors. In addition, in DIII-D, the dust density varies with the phase of the plasma discharge and plasma parameters. The dust density is roughly twice as large in ELMing H-mode discharges compared to QH- or L-mode. Supported by the US DOE under DE-FC02-04ER54698 and DE-FG02-04ER54758.

UP8.00044 Dependence of H-mode Power Threshold on Input Torque and Toroidal Plasma Rotation in the DIII-D Tokamak, P. GOHIL, General Atomics, G.R. MCKEE, D.J. SCHLOSSBERG, U. Wisc.-Madison, G. WANG, UCLA — The power required to induce the L-H transition is dependent on the applied beam torque. For upper single-null discharges in which the ion ∇B drift is away from the X-point, the L-H transition power threshold is reduced by up to a factor of 3 by changing from predominantly co (4-6 MW) to predominantly counter-injection (<2 MW). Lowered L-H transition power thresholds are also observed with reduced input torque in discharges with the ion ∇B drift towards the X-point, but to a lesser degree. For the first time, an H-mode transition was induced by slowly reducing the input torque at constant input power by slowly varying the mix of co- and counter-beam injection. The mechanisms for such a torque dependence are being investigated from analyses of the edge plasma rotation, the edge radial electric field and the edge plasma turbulence. Preliminary results indicate large changes in the poloidal velocity shear of the edge turbulent eddies prior to the L-H transition that may be strong enough to induce the transition. Supported by US DOE under DE-FC02-04ER54698, DE-FG02-89ER53296, and DE-FG03-01ER54615.

UP8.00046 Effects of Toroidal Rotation on Edge Turbulence and the L-H Power Threshold, D.J. SCHLOSSBERG, G.R. MCKEE, M.W. SHAFER, U. Wisc.-Madison, K.H. BURRELL, P. GOHIL, R.J. GROEBNER, T.C. LUCE, GA, G. WANG, UCLA— Edge turbulence dynamics, flows, and flow shear are found to depend strongly on the injected neutral beam torque in DIII-D plasmas. Likewise, the power threshold required to induce a transition from low- to high-confinement mode decreases by a factor of 2-3 as torque is varied from the co to counter current directions. Turbulence characteristics such as the poloidal shearing rates, correlation rates, and decorrelation times in the edge region are examined with the high-sensitivity 2D beam emission spectroscopy diagnostic on DIII-D. Poloidal flow shear in the turbulence is found to increase in all cases as the transition is approached. As the injected torque is varied from co-current to balanced, a bi-modal structure and strongly dispersive turbulence spectrum develops. At low-rotation this bi-modal structure consists of oppositely propagating flows that lead to flow shear rates increasing above the calculated decorrelation rates. Supported by the US DOE under DE-FG02-89ER53296, DE-FC02-04ER54698, and DE-FG03-01ER54615.

Friday, November 16, 2007 8:00AM - 9:00AM
Session XR1 Review: Instabilities Driven By Energetic Particles in Magnetized Plasmas
Rosen Centre Hotel Junior Ballroom

8:00 AM XR1.00001 Instabilities Driven by Energetic Particles in Magnetized Plasmas, WILLIAM HEIDBRINK, University of California, Irvine — Wave heating, beam injection, and fusion reactions create super-thermal ion and electron populations in both natural and laboratory plasmas. The free energy of the energetic particles often drive instabilities. In this review talk, the generic features of these instabilities will be discussed using a class of instabilities known as Alfvén eigenmodes, which occur in spectral gaps associated with periodic variations in the index of refraction. In the first observations of these instabilities, intense neutral beam injection into tokamaks drove instabilities in the spectral gap caused by toroidicity. Later observations worldwide showed the universality of this phenomenon with a wide variety of energetic populations driving instabilities in numerous spectral gaps in stellarators, pinches, and spherical and conventional tokamaks. The extraction of energy from the energetic particles necessarily alters their constants of motion, leading to a degradation in confinement. Both convective and diffusive transport are observed and, in extreme circumstances, the vessel walls are damaged. Recent diagnostic advances show that the measured mode structure is often in excellent agreement with theoretical predictions; on the other hand, the observed fast-ion transport is often larger than expected. The nonlinear dynamics is complex. In some circumstances, bursts of wave activity cause fast-particle loss, resulting in relaxation oscillations. In others, structures in phase space associated with a single coherent mode cause frequency sweeping. In still others, multiple unstable modes result in gradual flattening of the fast-particle pressure profile. The many possibilities pose a challenge for ITER, where intense alpha-particle populations are likely to excite Alfvén eigenmodes. Supported by US DOE under DE-FC02-04ER54698 and SC-G903402.

Appendix A

Agenda for "The first microns of the first wall" mini-conference at APS-DPP

Wednesday, November 14, 2007
2:00PM – 5:00PM
Chair: Daren Stotler, Princeton Plasma Physics Laboratory
Location: Rosen Centre Hotel - Salon 11/12

2:00-2:20 PM5.00001: Lithium and Deuterium on NSTX Carbon Tiles William R. Wampler, Charles H. Skinner, Henry W. Kugel

2:20-2:40 PM5.00002: The lithium deposition on NSTX plasma facing components by LITER-1 evaporator in 2006
Leonid E. Zakharov, Henry Kugel, Lane Roquemore, Charles Skinner

2:40-3:00 PM5.00003: Surface analysis of lithium coatings in NSTX J. Timberlake, H.W. Kugel, C.H. Skinner, N. Yao

3:00-3:20 PM5.00004: Mass changes in NSTX surface layers with Li conditioning as measured with quartz microbalances
C.H. Skinner, H.W. Kugel, A.L. Roquemore

3:20-3:40 PM5.00005: In-situ elemental and chemical state characterization of lithiated surfaces under energetic particle bombardment. Jean-Paul Allain, S. Harilal, M. Nieto, M.R. Hendricks, Ahmed Hassanein

3:40-4:00 PM5.00006: Physical sputtering and chemical erosion studies on plain and lithiated graphite samples Ramasamy Raju, Marin Racic, J. Lee, David Ruzic

4:00-4:20 PM5.00007: Liquid lithium self-propulsion under applied heat loads Michael Jaworski , Cheuk Lau, Madison Malfa, David Urbansky, David Ruzic

4:20-5:00 Discussion

Thursday, November 15, 2007
9:30AM – 12:30 AM
Chair: Tom Rognlien, Lawrence Livermore National Laboratory
Location: Rosen Centre Hotel - Salon 11/12

9:30-9:50 TM5.00001: Review of C-Be mixed material plasma experiments in PISCES-B J. Hanna, D. Nishijima, R.P. Doerner, M. Baldwin, K.R. Umstadter, R. Seraydarian, R. Hernandez

9:50-10:10 TM5.00002: Mixed plasma species effects on Tungsten Matt Baldwin, Russ Doerner, Daisuke Nishijima, Yoshio Ueda

10:10-10:30 TM5.00003: Sputtering, impurity transport, and redeposition at the divertor and first wall Jeffrey N. Brooks

10:30-10:50 TM5.00004: Hydrogenic Fuel Retention in Refractory Metals D.G. Whyte, B. Lipschultz, J. Irby, G.M. Wright

10:50-11:10 TM5.00005: Effect of impurities on the thermo-oxidative removal of codeposits from DIII-D and JET divertor tiles A.A. Haasz, C. Tsui, J.W. Davis

11:10-11:30 TM5.00006: Innovative Tokamak First Wall and Divertor Material Concepts C.P.C. Wong

11:30-11:50 TM5.00007: Evolution of Elemental Composition and Morphology in Fusion Reactor's First Wall Yong W. Kim

11:50-12:10 TM5.00008 – postdeadline: Effect of Carbon Re-Erosion in ITER A.S. Kukushkin, H.D. Pacher

12:10-12:30 Discussion

2:00PM – 5:00PM
Chair: Sergei Krasheninnikov, University of California at San Diego
Location: Rosen Centre Hotel - Salon 11/12

2:00-2:20 UM5.00001: In-situ investigations of material migration in recent JET campaign A. Kreter

2:20-2:40 UM5.00002: Chemical Sputtering of graphite surfaces by slow H and D Atomic and Molecular projectiles
F.W. Meyer, H. Zhang, H.F. Krause

2:40-3:00 UM5.00003: MD Simulations of Plasma-Surface Interactions of Deuterated Carbon P.S. Krstic, C.O. Reinhold, S.J. Stuart

3:00-3:20 UM5.00004: Structural Studies of Carbon Dust Samples Exposed to NSTX Plasma Yevgeny Raitses, Charles H. Skinner, Fuming Jiang, Thomas S. Duffy, Angus Pacala

3:20-3:40 UM5.00005: Hydrogen dynamics under strong plasma-wall coupling A.Yu. Pigarov, S.I. Krasheninnikov, A. Pletzer

3:40-4:00 UM5.00006: Investigation of Plasma Surface Interactions with the PISCES ELM Laser System
K.R. Umstadter, M. Baldwin, J. Hanna, R. Doerner, T. Lynch, T. Palmer, G.R. Tynan

4:00-4:20 UM5.00007: Atomistic Simulations of Energetic Particle Interactions with the First Wall. Roger Stoller

4:20-5:00 Discussion