Transport and Confinement ITPA Task Group Annual Report: 2009–2010

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The Transport and Confinement Topical Group held two meetings this past year. The first was held on Oct. 5–7 in Princeton, NJ, USA following the IAEA TCM on H-mode and Transport Barrier physics. This meeting was joint with the Pedestal group, and the joint session included reviews and discussions on several L-H threshold physics topics, including species dependence, access to good confinement regimes, hysteresis, dependence of threshold on rotation, hidden variables and theory. Other topics discussed during this meeting were databases, specifically the momentum database, electron transport, transport model validation, and the status and plans for

TC-9	Scaling of intrinsic rotation with no external momentum input	C-Mod/TCV similarity expt.
TC-10	Expt'l identification of ITG, TEM, and ETG turbulence and comparison to codes	Ongoing Joint Activity Couple to TC-11, study ETG for electron transport
TC-11	He profiles and transport coefficients	Joint Activity; call for data
TC-12	H-mode transport at low aspect ratio	NSTX (low n*), MAST (q-scan)
TC-13	ITG critical gradient and profile stiffness	C-Mod (active), JET
TC-14	RF rotation drive with ICRH, LH and ECH	C-Mod, JET, DIII-D, AUG, JT-60U, EAST (?); LHCD/ECH
TC-15	Dependence of momentum and particle pinch on n^*	NSTX, DIII-D, JET (AUG) Reassess in 2010
TC-16	Physics model validation during current ramp-up phase	Ongoing Joint Activity
Being considered	Determination of "residual stress"	DIII-D, NSTX, JET, JT-60U
Being considered	Effect of non-axisymmetric fields on L-H threshold (EF vs rotation dependence?)	DIII-D, JET, MAST, NSTX
Being considered	Electron transport induced by microtearing, fast-ion driven modes	NSTX, MAST, AUG
Being considered	Pellet fueling, pellet-induced particle transport	Cross-cutting working group topic

In addition to the above experiments and activities, database work is still ongoing, although to a lesser extent than in previous years. The status of the databases is given below:

1. Momentum database (M. Yoshida)

and reducing uncertainties in P_{LH}. The plan is to discuss details (data, validation) at dedicated experiments and analysis of data already obtained. It was felt by all that the priority of this ITPA work should be elevated to the highest level. The I-mode, observed on C-Mod, AUG and DIII-D was also discussed as a possible operation scenario for ITER. The I-mode has H-mode like energy confinement (0.8-1xH), but L-mode like particle confinement, and, therefore, no ELMs. The I-mode can be obtained only at high power in, so far, a counter-injection plasma; i-mode rh m i o g d h e 0w e

Tang model does not also have the virtue of reliably predicting the peripheral temperatures (although the central temperatures are frequently acceptable). Another important lesson is that superficially small differences in electron temperature profiles measured by different diagnostics can produce very significant differences in predictions of current penetration timescale (as determined by time of first sawtooth, for example). Solid documentation of all experiments will be needed for transport model validation.

Simulations of ITER similar current ramps in DIII-D also demonstrate shortcomings of the Coppi-Tang model (again in the periphery), but simulations of current profile evolution based on measured T_e served to validate the neoclassical model for parallel conductivity (a validated conductivity model is also necessary for ITER predictions).

The EUISM effort is led by a several people using three transport codes, which were said to have been benchmarked successfully against each other. This effort added data from Tore Supra and AUG to six JET shots (some of which are outside the set used above by Voitsekhovitch and Budny). Again the Coppi-Tang and GLF23 models did not fare well, while the Bohm-gyroBohm model was often acceptable. ITER peaking occurring only for on-axis heating with P_{ECH} > 0.7MW. Similar related observations have been previously seen in DIII-D and JT-60U. Intrinsic rotation in JET ICRF-heated H-modes showed that the rotation was counter-current, and did not exhibit any scaling with plasma pressure. This result is a mystery. Studies on Tore Supra used an approach which was to vary the edge ripple to control edge rotation in order to study the effect on v_{pinch} and intrinsic rotation. In the case of Tore Supra, the ripple could be increased to 7%. By varying the plasma size to change the edge ripple, ion loss due to toroidal field ripple was found to induce counter-current rotation. The rotation was found to increase in this counter direction with both increasing P_{ICH} and P_{LH}, with no change in the edge rotation. Experiments on C-Mod were devoted to a TCV similarity experiment on rotation inversions which occur at a very precise density threshold. An L-mode rotation database is being populated for comparison with other devices, notably JET and TCV. Rotation in I-mode on C-Mod exhibits characteristics similar to H-mode. The core H-mode rotation was found to depend on the local pedestal pressure gradient, suggesting a role of the residual stress in driving the rotation. Direct measurements of vorticity fluctuations and intrinsic poloidal rotation were reported on CSDX, and the correlation with the residual stress. They were able to measure the total and diffusive stress, and subtract the two to find the residual stress that was related to collisional drift wave turbulence. Potential fluctuations in the edge velocity shear layer of TJ-II plasmas and a bifurcation of their propagation direction at the separatrix were found to depend on the density. A rotation sink in JET plasmas due to drag from neutrals was reported.

Momentum fouE61 TfTad(prophear)Tj /C2_0 1 Tf 01vnd -0.009 Td 0.225 l0%(s<D/V ClD01 >>BDC that a total convection directed outwards is usually difficult to obtain in simulations of plasma conditions at which it is observed, particularly for impurities like B or C. In addition, emphasis has been given to the role of turbulent diffusion of impurities, and it has been suggested to make specific comparisons between theoretical predictions and experimental observations on this parameter, applying proper normalizations, in particular the ratio of the impurity diffusivity to the effective heat conductivity.

past observations of He transport in DIII-D were reviewed. He density profiles have been measured for a variety of plasmas in stationary conditions, and transient transport experiments with He gas puffs have allowed the measurement of the He diffusivity and convection. The main result is that the He density profile is found to have the same shape of the electron density profile in all types of discharges, independent of the edge source or sink. Using He gas puffs to estimate the D and F it was found that both are in the range of a few m^2/s and a few m/s respectively. In particular, D was found to scale as gyroBohm in the core, but as Bohm farther out, similar to results for the thermal diffusivity. Present plans are to contribute with published âôsðSÚÂ ðÂ _ ' Ð 0 current. An inward convection

observed values of R/L_{ne}, unless turbulence producing much larger (electron) heat transport than particle transport is at play.

ITB formation and evolution with co and counter NBI in MAST using high resolution kinetic and q asion ITBs or hybrids. The commonly used quenching rule of turbulence by ExB flow shear indicates only a threshold up shift, and it was proposed to re examine an alternative version of it that is supported by non linear fluid turbulence simulations of Resistive Ballooning Modes This alternative version foresees also a change in stiffness, more consistent with JET experimental results.

Non linear simulations of ITB formation due to ExB or magnetic shear were presented. Barriers are seen in codes with externally imposed ExB shear and also with self r generated zonal flows, but in slab cases and at rather large U only. The externally imposed or self generated ExB shear is seen to affect stiffness, reducing growth rates by a factor $1/(1+a_{ExB}^2)$. In present simulations, however, the self generated E_r is not consistent with neo classical transport. Low magnetic shear is not generally seen to trigger barriers because of the presence of non resonant modes. However in the case of low s and q_{min}=2, reduced transport was seen in GYRO. In the future we will be in better position to explore such issues with the availability of global, g l o b a lð,Ã ðÁ6PÓ \ % 0À , % ºì 2.

On the operational side, since ITER needs core improved confinement for steady-state AT scenarios:

- In which channels is it reachable? Or wanted? ITG dominant so rotation needed. More experiments trying to achieve ion improved confinement without NBI rotation?
- Which q profile is preferred? Strongly reversed, mildly reversed, flat? q_{min}~4 or q_{min}~2?
- Is a JT-60 like scenario with early heating, high q_{min}, strongly reversed q technically achievable in ITER? It is not in JET due to NBI shine-through
- Avoid impurity accumulation with RF in ITBs: more results in addition to JT-60?

Summary

The high priority items outlined in the ITER R&D document are still relevant, and the work plan for 2010-2011 for the T&C group will not be significantly changed. We see more work done on transport model validation and L-H thresholds. In addition, we plan to develop more JEXs on electron transport and participate in a working group topic on pellet injection and fueling.