TC-13 Ion and electron critical gradient and profile stiffness

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| **TG priority:** High | **Start date:**   | **Status:**  On-going | **Personnel exchange:**  Yes |
| **IO priority:**   | **End date:**   | **Motivation:**   |

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| **Device /****Association** | **Contact****Persons** | **2016 TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| JET  | P. Mantica | Desirable | Committed | Considering | Committed | Analysis |   |
| DIII-D | C. PettyT. Luce | Desirable | Committed | Considering | Analysis | Analysis |   |
| MAST | A. Field | Desirable | Committed | Committed | Done |   |   |
| AUG | G. TardiniC. Angioni | Desirable | Committed | Committed | Considering | Considering |   |
| C-Mod | J. Rice, Y.Lin | Desirable | Committed | Analysis | Analysis | Analysis |   |
| NSTX-U | Y. Ren | Desirable |   |   |   | Analysis  |   |

**Purpose:** The study of ion and electron threshold and stiffness and their parametric dependences at different radii in plasmas in various regimes. This involves both experiments and theory validation.

**Results for 2015**

* JET: experiments showing the stabilizing effect of s on TEM threshold have been found in good match with linear GK predictions. The experimental electron stiffness level was found higher than that yielded by non-linear GENE simulations of ITG-TEM. Initial simulations of ETG scales using ExB flow or electron zonal flows as saturation mechanism indicate a significant ETG-driven electron heat flux. However proper multi-scale simulations are needed to validate this result.
* JET: The 2 new sessions on effect of N on ITG threshold/stiffness have been analyzed. Increasing N level, ions are found to become stiffer, leading to a decrease of Ti peaking, whilst no effect on threshold is seen (at variance with predictions). Instead electron temperature peaking increases with N level, possibly due to ETG stabilization due to increased Te/Ti\*Zeff.
* DIII-D: Analysis of ion stiffness experiments was completed. Transport in the low torque scan is higher than that in the co-NBI scan. The difference is consistent with an ExB shear effect, whilst Ti/Te can be excluded as the cause. A weak power degradation is observed and is consistent with a favorable dependence of transport on Ti/Te. The change in transport behavior from ρ=0.4 to ρ=0.7 is consistent with a strong favorable dependence of transport on βfast.
* MAST: GK simulations of near-marginal turbulence in L-mode plasmas held good match of experimental heat flux at values of gamma\_E and R/L\_Ti within the experimental uncertainties. Parameters of synthetic turbulence from the matched simulation are found to be in good agreement with observations.
* MAST: BES measured parameters of ion-scale turbulence are found to be strongly affected by finite spatial resolution, particularly the eddy tilting. A method has been developed to deconvolve these effects and revisit previous results on the dependence of the eddy tilting and turbulent heat flux on flow shear.
* NSTX: Fast reduction in high-k turbulence and in electron energy flux after RF heating cessation in NSTX RF-heated L-mode plasmas are further investigated with global gyrokinetic simulations using GTS. GTS simulations show that the predicted electron and ion energy fluxes are similar before and after the RF cessation, consistently with the small change in equilibrium profiles. The GTS-predicted electron energy flux is in agreement with the experimental values after the RF cessation but is significantly under-predicted before the RF cessation. These results together with local nonlinear simulations performed previously show that profile stiffness and profile variation mechanisms have difficulty in explaining the experimental observations and non-local flux-driven mechanism may be important.
* Modelling: the physics of e.m. ion destiffening has been thoroughly benchmarked between GENE and GYRO finding good agreement between the two codes on selected JET data. The non-linear e.m. effect has been confirmed to the dominant mechanisms with respect to ExB flow shear in the central region of the chosen JET shots. A new saturation model has been implemented in TGLF (TGLF-M), which accounts for coupling between electron and ion scale transport. TGLF-M reproduces well the GYRO simulations, including the Dimits shift, and has the potential of solving some edge shortfall issues, improving predictions of high beta scenarios. It yields a 19% increase of performance in ITER predictions.

**Plans for 2016**

TC-13 is proposed for continuation throughout 2015, with new experiments in plan at JET and under consideration in DIII-D and significant analysis and modeling of previous results in JET, DIII-D, MAST. Model development and validation is also in progress.

* JET: 2 sessions are in plan to study non-linear e.m. stabilization in plasmas with low rotation (scheduled in January 2016) and the role of ETGs (planned as back-up experiment).
* DIII-D: complete modeling of ion stiffness experiments. Possible further proposals but discussion on experimental planning still to be carried out.
* MAST: revisit previous results on the dependence of the eddy tilting and turbulent heat flux on flow shear. Global TRINITY simulations to be run for MAST cases with/without significant ion-scale turbulence.
* AUG: experiments are planned in the 2015-2016 campaign to investigate the dependencies on the temperature gradients and their ratio by varying the heat flux with on- and off-axis NBI and ECRH.
* NSTX: investigate profile stiffness with the new high-k scattering system in similar and different regimes with respect to those explored in 2015.
* Modelling: investigate how the non-linear e.m. stabilization could be included in quasi-linear models to improve their reliability in particular for AT scenario predictions. Implement TGLF-like multiscale saturation model in Qualikiz.