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Summary of Theory Papers

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Papers : TH 227 (OV 2, Oral 28, Poster 197)

Reference 2018 (India): 167, 2016(Kyoto)： 203

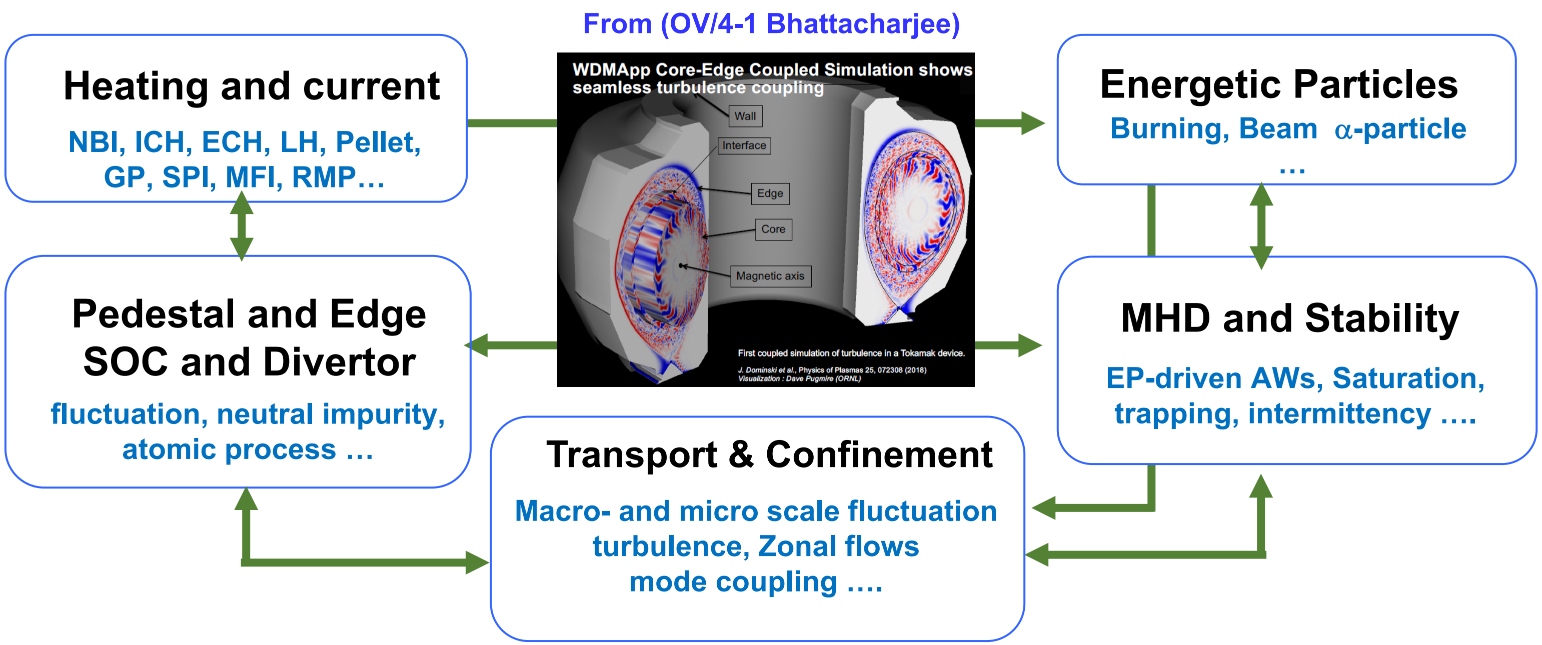
Contents

Each topics not independent, but tightly couple each other

Contents

1. Transport and Confinement
2. MHD and Stability
3. Energetic Particles
4. Pedestal and Edge, SOL and Divertor
5. Disruption and Runaway Electron
6. Heating and current dive
7. ITER and others

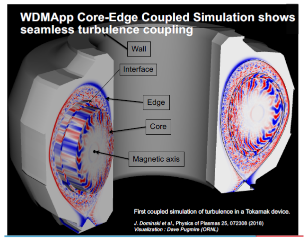
- Individual processes
- Interactions and connection among them leading to comprehensive understandings and future directions



Two key approaches: **Multi-scale & multi-physics integrated large scale simulation**

OV/4-1 A. Bhattacharjee

Grand challenge to integrate a suit of codes based on gyro-kinetic modeling to construct a whole device model, which connects among different processes with different spatio-temporal scales, but keeping micro-scale structure and dynamics.



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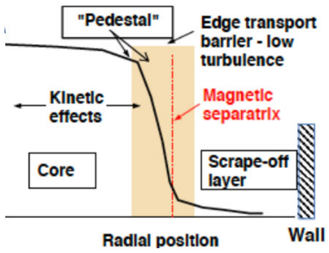
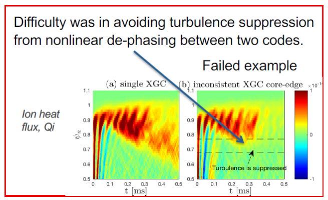
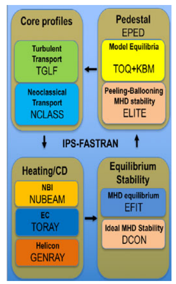


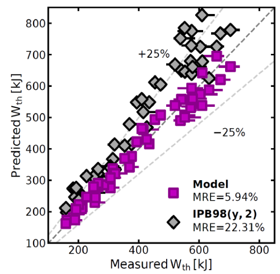


- Kinetic (phase space) level coupling requested

OV/2-5 G. M. Staebler

Theory based predictive modelling which includes all available components but well validated by the first principle simulation and experimental data, incorporated with Deep Learning



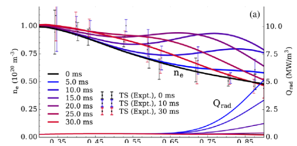


Modeling workflows was tested, being accurate than 98(y,2) scaling

"predict-first Initiative" toward experimental prediction and planning

- Calculation of each physics component must be reduced to tractable level, based on local transport paradigm.

cf. Explanation of inversion of cold pulse dynamics can be explained by local quasi-linear model.



Rodriguez-Fernandez et al PRL.(2018)

Two key approaches: **Multi-scale & multi-physics integrated large scale simulation**

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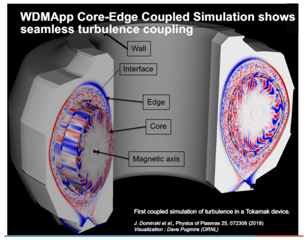

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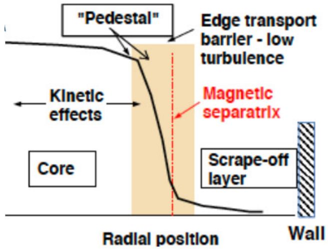

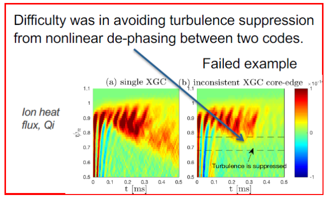

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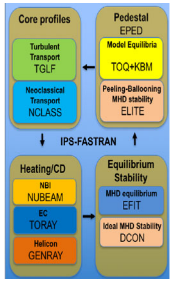

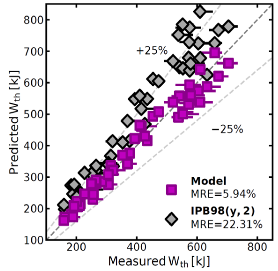

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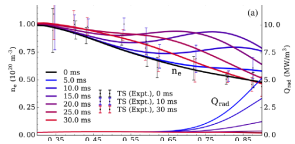
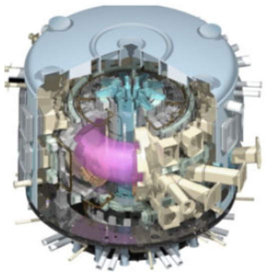


Rodriguez-Fernandez et al PRL.(2018)

ITER Plasma: a new state

- **local** or **non-local (global)**
- **diffusive** or **non-diffusive**
- **quasi-linear** or **non-linear**
- **real space dynamics** or **phase space dynamics**
- **deterministic** or **probabilistic**

……



higher non-dissipative
"phase-space medium"
keeping
"long time memory"

Theory-based modelling

(Understand core physics)

Data-based modelling

(Achieve real time prediction)

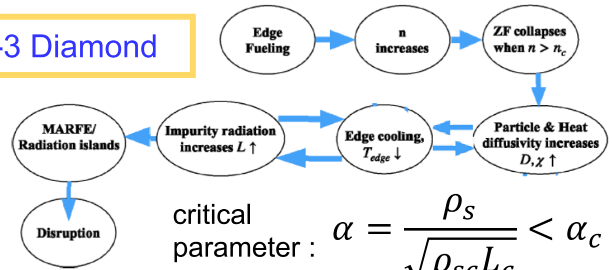
1. Transport and Confinement

1.1 Zonal flow related theory & sim.

- **New theory of zonal flow**

Origin of density limit results from **shear layer collapse** near edge, which leads to ZF collapse for a< a_c, by the break of turbulence-ZF feedback loop due to the neo-classical screening leading to particle/heat diffusion.

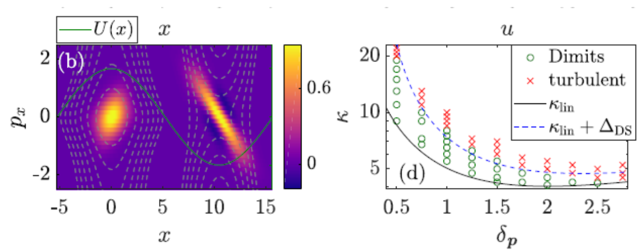
TH/P5-3 Diamond



critical parameter : $\alpha = \dfrac{\rho_s}{\sqrt{\rho_{sc} L_c}} < \alpha_c$

The effect of **tertiary instability** with growth rate γ_{TI} driven by zonal flows on the Dimits shift is studied in WH model, so that γ_{TI} =0 determines the effective shift value.

TH/P5-5 Zhu



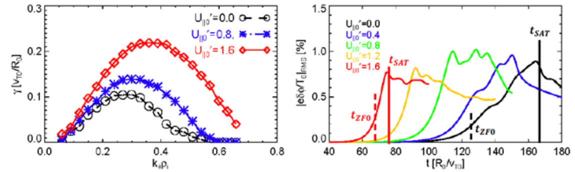
Theoretical framework describing transport in mixed zonal flow and turbulent system, **zonal state**, is presented, by considering the state as a kind of plasma equilibrium with residual EM fluctuation.

TH/P5-7 Falessi

- **Recipe to enhance zonal flows**

A system linearly more unstable by toroidal rotation leads to the plasma with zonal flows with higher amplitude using gKPSP, global df PIC

TH/P5-12 Yi



A new trend to use zonal flow more actively to control fusion plasma by extending the theoretical methodology.

1. Transport and Confinement

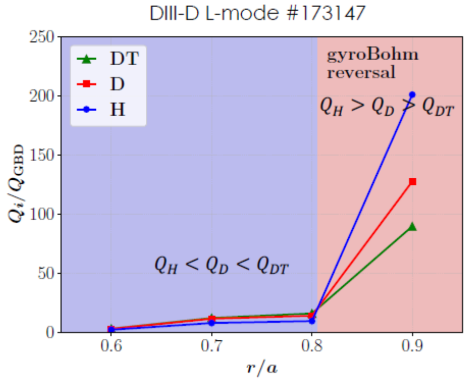
1.2 Isotope effect

A new isotope-mass scaling law dominated by electron parallel non-adiabaticity to magnetic drift scale (α<1), where e-ion mass ratio is multiplied to GB. Reversing GB to higher heat flux Q in edge region (CGYRO)

$$Q_i \propto \left(\frac{m_e}{m_i}\right) Q_{GBi}$$

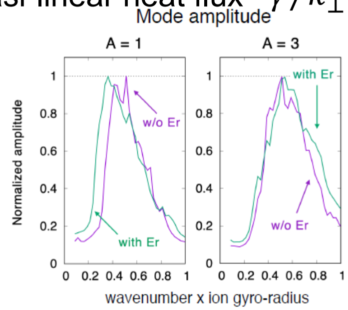
$$\alpha = \frac{\tau_e}{\tau_d}$$

TH/5-1 Belli

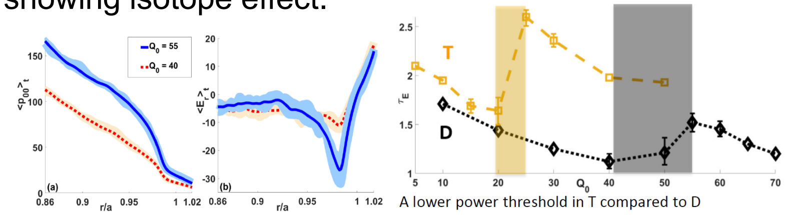


Hydrogen isotope is studied with a given radial electric field using XGC-S in LHD. No difference in linear growth rate, while the wave number becomes smaller in D plasm, leading to smaller quasi-linear heat flux $\gamma/k_\perp^2$

TH/P5-16 Moritaka



Pedestal H-mode formation is studied using EM fluid code EMEDGE3D. Tritium plasma leads to lower threshold H-mode power getting higher τ_E than D, showing isotope effect.



TH/P6-2 Bourdelle

Mechanism of isotope effect : reference from TH/5-1

- $\vec{E}\times\vec{B}$ flow shear (Garcia NF 17)
- Electromagnetic fluctuations (Garcia NF 17, Manas NF 19)
- Collisions (Nakata PRL 17, Bonanomi NF 19)
- Impurities (Pusztai PoP 11)
- Fast ions (Garcia NF 18, Bonanomi NF 19)
- Kinetic electrons (Estrada PoP 05, Pusztai PoP 11, Bustos PoP 15)

1. Transport and Confinement

1.3 transport barrier

- **ITBs and ETBs**

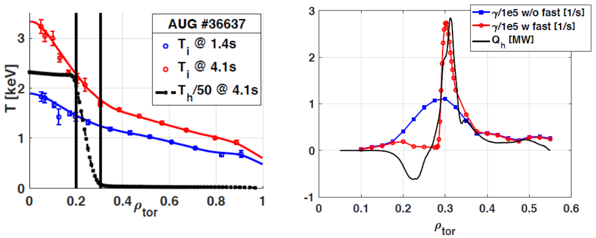
TB formation
→ How to induce localized Er shear layer

$$E_r + \frac{k}{e}\frac{\partial T_i}{\partial r} - \frac{rB}{qR}U_\parallel - \frac{1}{n_i e}\frac{\partial p_i}{\partial r} = 0$$

- turbulence drive
- NC drive
- flow drive
- ....

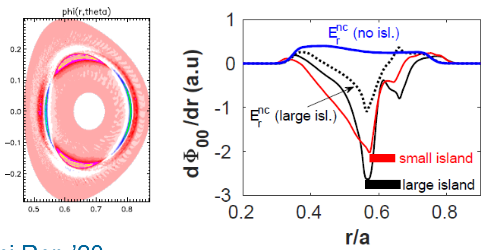
Anomalous ITB by **ICH driven fast ions** obtained in AUG based on stabilizing/destabilizing characteristics of ITG turbulence (GENE).

TH/4-1
Di Siena



Magnetic Island induced localized helical E field across inner boundary leading to ITB from global ES GK simulation.

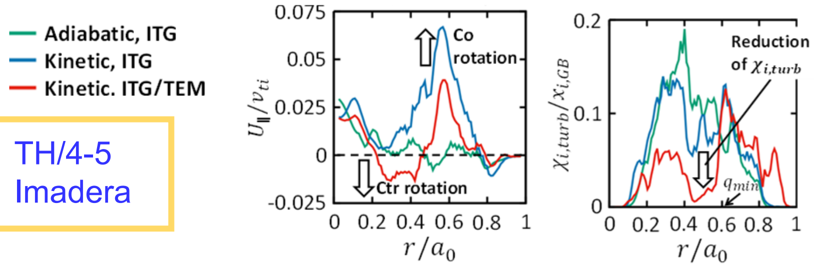
TH/4-3,
Wang



cf Kenmochi et.al., Sci Rep.'20
Movement of ITB foot with island (H-J)

ITB formation in reversed magnetic shear plasma with mixed **ion/electron heating**, which induces TEMs, leading to U|| and strong Er shear, from global flux driven GKNET.

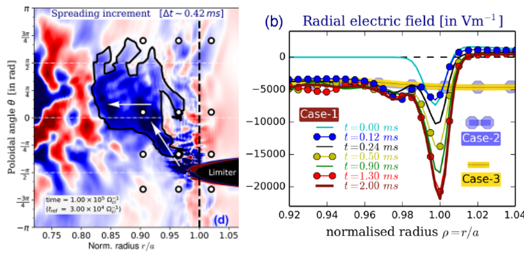
TH/4-5
Imadera



Global flux driven GYSELA with **limiter**, where turbulence is excited and diffuse inside, leading to localized Er field and then ETB formation.

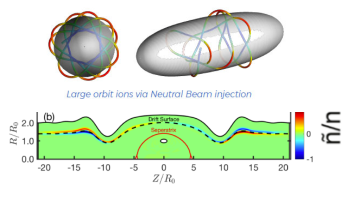
TH/4-4
Dif-Pradalier

Kenmochi et al.,
Sci. Rep.'20

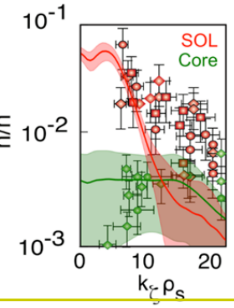


Computational Studies of a beam-driven C-2 FRC with a large energetic ion population have been progressed, developing GTC-X + ANG (3D cross-separatrix PIC)

TH/P7-1 Lin,
TH/P2-19
Dettrick



Turbulence spreading
from SOL to core in FRC



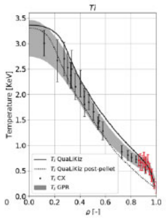
1. Transport and Confinement

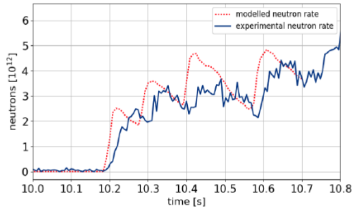
1.4 developing of modelling

Dynamical prediction by flux-driven multi-channeling integrated modelling of JET-DT scenario using NN based on QuaLiKiz reduced turbulence model, relying on quasi-linear for $0.5<k_\theta\rho_i$

TH/5-2 Citrin
TH/P2-23, Marin

TH/P7-20
van de Plassche

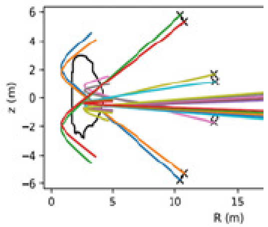




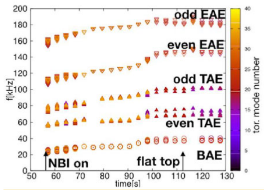
Coupled with NN surrogate model

Predictive Multi-Physics Integrated Modelling of Tokamak Scenarios developing ITER integrated modeling and analysis Suite (IMAS) as European Transport Simulator (ETS)

JT60SA non-inductive CD



EP stability



TH/P2-20 Romanelli
TH/P2-22 Pinches
TH/P2-25 Rafig

TH/P2-21 Manas (Tungsten transport by ASTRA+QuaLIKiz)

TH/P2-26 Mantica (Divertor Tokamak Test facility ,QuaLIKiz)

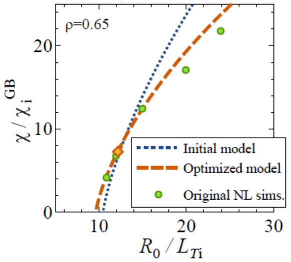
TH/P2-4 Stancar (Neutron emission integrated modelling in JET)

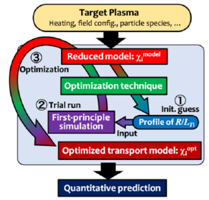
TH/P2-15 Tardini (furry predictive transport modelling in AUG with QL validation)

TH/P5-4 Heinonen (1D reduced model + HW system)

Prediction of turbulent transport by combining QL transport model and GKV sim., optimization technique using NN

TH/5-3 Nunami :



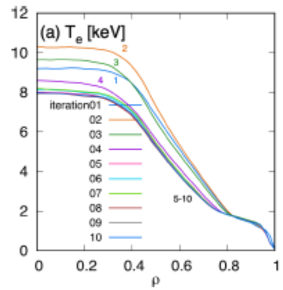


Prediction of turbulent particle and heat fluxes quickly with machine learning, DeKANIS

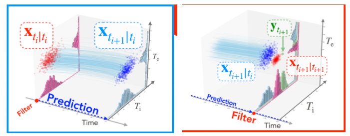
TH/P7-7 Narita :

Exact steady-state solution is obtained by global optimization and robustly transport model, GOTRESS+ (include EPED1, MARGE2D, TGFL)

TH/P2-5 Honda :



Data assimilation approach using simulation and exp. with Deep Learning



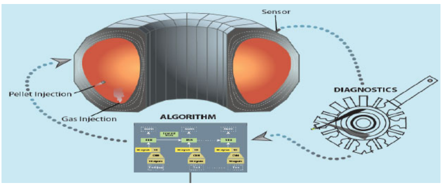
TH/P5-22 Morishita (TASK3D and LHD exp.)

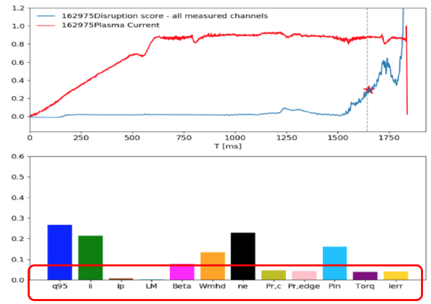
1. Transport and Confinement

1.5 AI/DI based predictor for avoiding imminent events for machine safety

(e.g. disruption, anomalous thermal/EM load)

FRNN predictor available using 2D profile data introduced into DIIID PCS with physics based sensitivity score

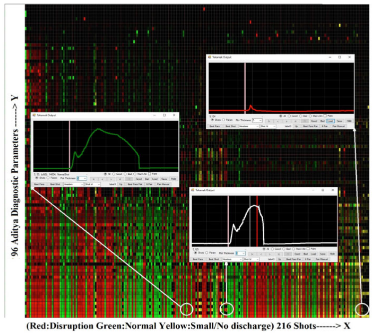




Q95, ℓ_i I_p LM β W_{MHD} N_e P_{rc} P_{edge}, Pin Torq

TH7-IR, Tang

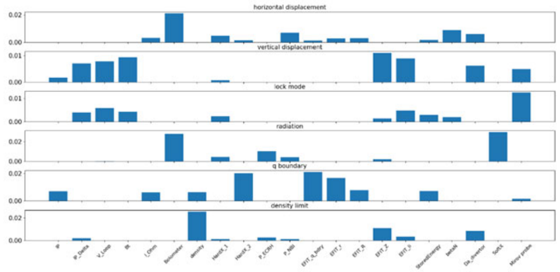
Automatic classification of ADITYA date based on information density for quick 2D data visualization



216 shot classification

TH7-IR, Bandyopad

Bayes classifier is developed to recognize the cause of disruption based on the output of the interpretation algorithm.

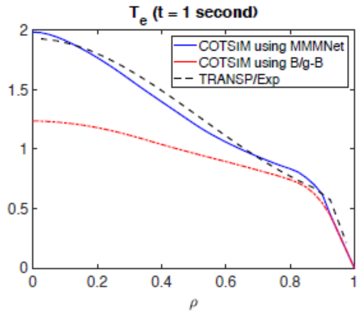


Importance of each input signal
for disruption cause

Yang TH7-IR

Principle component analysis to reduce TRANSP training data with 2D profile information using MMM to scalar quantities (dimension compression) for time dependent analysis

Morosohk TH/P5-10



Prediction of the T_e profile (keV)

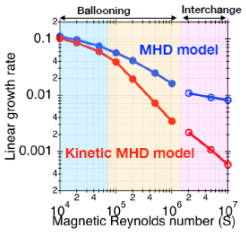
To accurately realize real-time prediction, enough "good" training data and "efficient" training algorithm are necessary

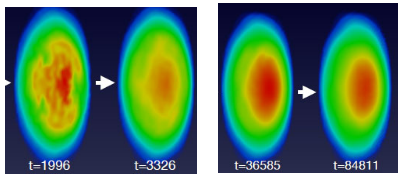
2. MHD and Stability

2.1 Core MHD and Stability

Stabilizing effect for MHD modes by the precession drift motion of thermal trapped ions is found in LHD plasma in hybrid MHD code MEGA (DK ion) which is effective in high Reynolds number regime.

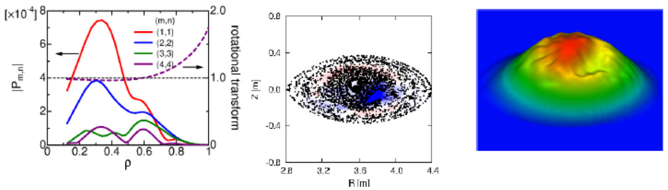
TH/7-5
Sato





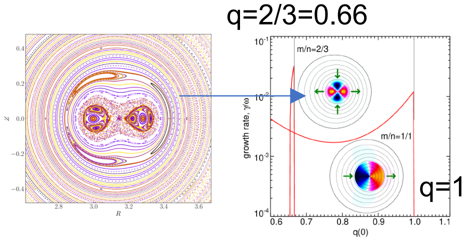
Mode transition in week shear plasma with net current in LHD from higher interchange mode to non-resonant global m=1 mode, leading to collapse, consistent with exp. using MIPS, compressional MHD code.

TH/P3-4,
Ichiguchi



The minimum achievable q0 in tokamak safety factor by the mechanism of appearance of 2/3 ideal mode which causes magnetic chaos around the axis.

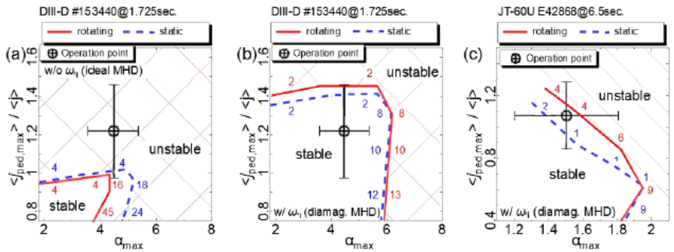
TH/P3-1 Smiet



2.2 Edge MHD and Stability

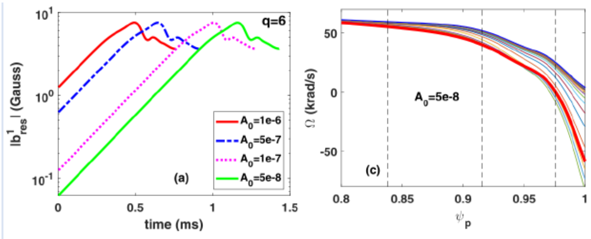
Linear stabilities of PB mode are studied including toroidal rotation and ion-diamagnetic drift effects using NINERVA-DI which explains stability window leading to QH-mode in DIIID and JT60.

TH/P3-2
Aiba



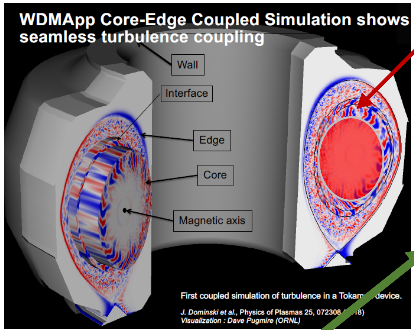
Non-linear kink-peeling mode dynamics are studied using MARS-K/Q with kinetic effects, flows (DIIID) …., observing large change of rotation profile after mode saturation, leading to EHO.

TH/P5-6
Dong



3. Energetic Particle

From (OV/4-1 Bhattacharjee)



Energetic particle (EP)
(generation, distribution, relaxation, transport ..)

EP driven MHD/Alfven waves, kinetic waves …
(linear dispersion, saturation, chirping, mode coupling …)

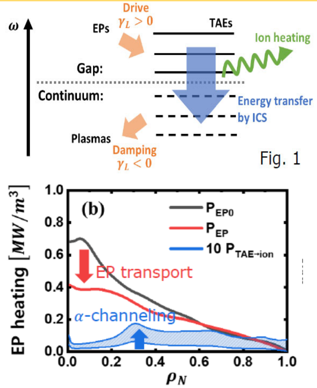
Background ES/EM turbulence, island …
(interaction, energy transfer…)

Effect on edge/SOC plasma
(structure, heat load ….)

Saturation mechanisms of Alfven waves due to Compton scattering, nonlinear trapping, zonal flow and field, bulk ion heating are discussed, which can be related to a-channel, so can be a key processes

THP/1-23 Seo

THP/1-23 Seo
High-n multiple TAE and heating nonlinear dynamics due to Compton scattering

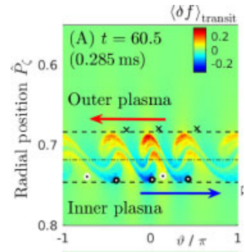


THP/4 Shaing,
Non-linear trapping and dissipation rate

TH/P1-1 Qiu
Saturation model including generation of zonal flow/field and ion Compton scattering

TH/P1-28, Romanelli
a-channel using sufficiently large amplitude IBW by stochastic kicks

Complex phase space multiple EPs dynamics dominated by stair-like "chirping" and "avalanche", also beating with hole/clump using ORBIT



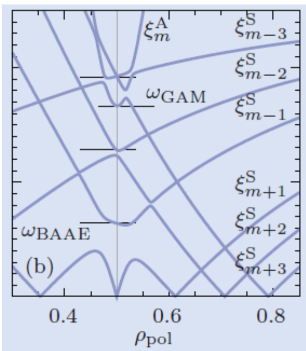
THP1-13, White

3.1 Linear / Nonlinear Theory

Comprehensive linear GK study of EP induced Alfven-eigen mode with diamagnetic effect and trapped particle resonance, BAE, KBM, beta induce acoustic Alfven (BAAE) branches.

TH/P1-2 Zonca

Higher order Geodesic AEs (HOGOEs) by elongation as a candidate of AE with half TAE frequency in JET is presented.

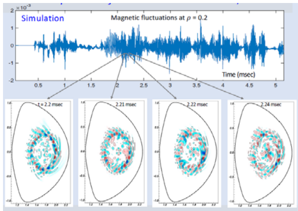


TH/P1-18 Rodrigues

3.2 Non-linear simulation

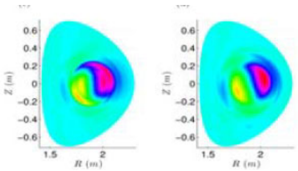
- **Hybrid approach :**

EP induced AW dynamics in DIIID RS plasma with zonal flow and field, mode coupling. Intermittent P-P cycles exhibiting subsequent structure change, using FAR2d/TAEFEL.



TH/P1-8 Spong

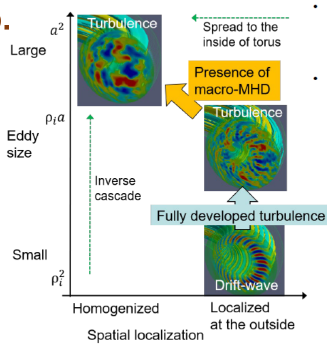
Fish-bone induced dynamics in reversed q-profile, exhibiting to dual resonant FB and non-resonant FB and saturations, using M3DK



TH/P1-12, Shen

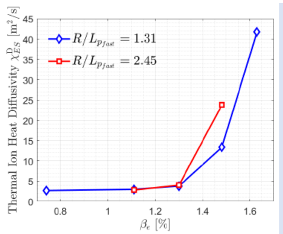
- **Interaction between and ES/EM turb.**

Interaction between KBM and TAE using a global EM GK, GKNET. TAE causes dual turb. cascades to lower wave number and to good curvature region, leading to a thermal transport enhancement



TH/4-2 Ishizawa

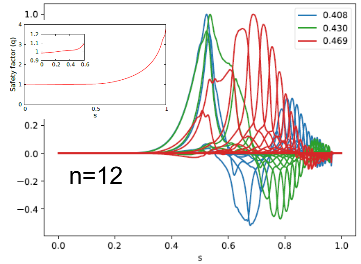
ITGs are stabilized by EP leading to confinement increase due to enhance ZF response, while weak on TEMs, using local GENE. In higher β, FI driven mode cause thermal turbulent transport.



TH/P1-5, Mazzi

- **EP driven mode including V&V**

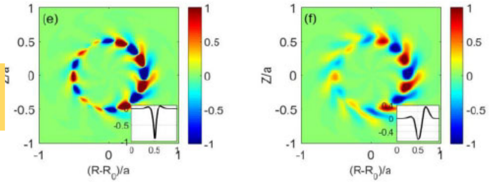
Linear / nonlinear simulation of EP driven AWs (TAE, EPM, EGAM) in AUG and ITER (15MA) scenario using a global EM GK-PIC ORB5 (n=10-40 identified for ITER).



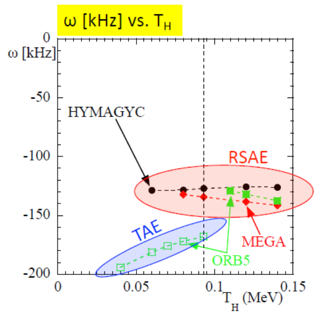
TH/P1-14 Schneider

Global BAE dispersion by trapped energetic electrons observed in HL2A and mode characteristics (symmetry break) are studied, leading to residual Reynolds stress.

TH/P1-31 Ma

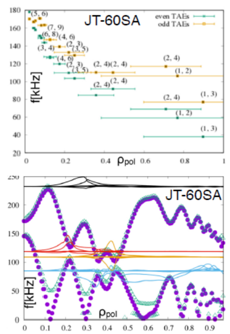


Benchmark among different code simulating the interaction between EP and SAWs for ITER, JT60SA , MYMAGYC (hybrid), MEGA (hybrid), ORB5 (GK) .



THP/1-3 Vlad

EP driven AWs and transport study by off-axis NB heating on AUG, JT60SA, ITER pre-fusion plasma. Wide variety of phase space structure and Aws, is identified using MEGA, LIGKA, HAGIS etc.

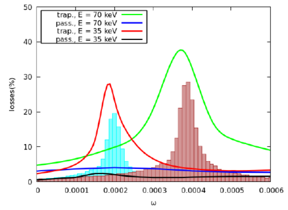


TH/P1-20 Lauber

- **EP Loss by MHD modes**

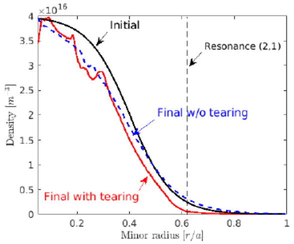
Loss of NB driven trapped EP by NTMs due to resonance, observed DIIID, AUG, is studied using FOCUS.

TH/P1-6 Ferrari



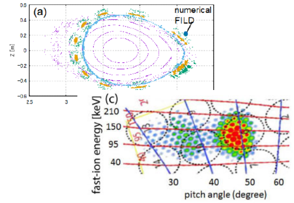
EP loss by single helicity tearing mode (DIIID, AUG, EAST) and even GAM (DIIID) using GTC due to higher order harmonics and by large orbit. Causing stochasticity.

TH/P1-21 Zarzoso



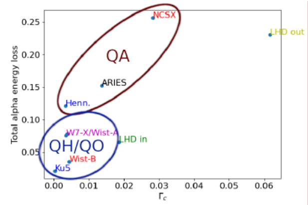
EP in divertor region in LHD exp. with AE bursts is compared with MEGA results, showing agreement with helical symmetry structure and pitch angle distribution.

TH/P1-10 Seki

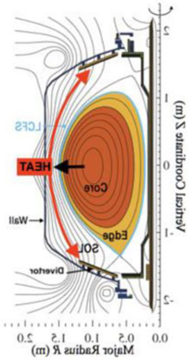


Study of optimized stellarator for EP transport (QA, QH, LHD ..)

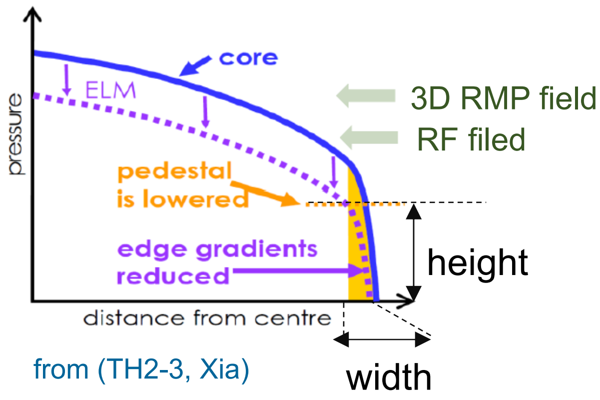
TH/P1-19 Bader



4. Pedestal & Edge, SOL & Divertor



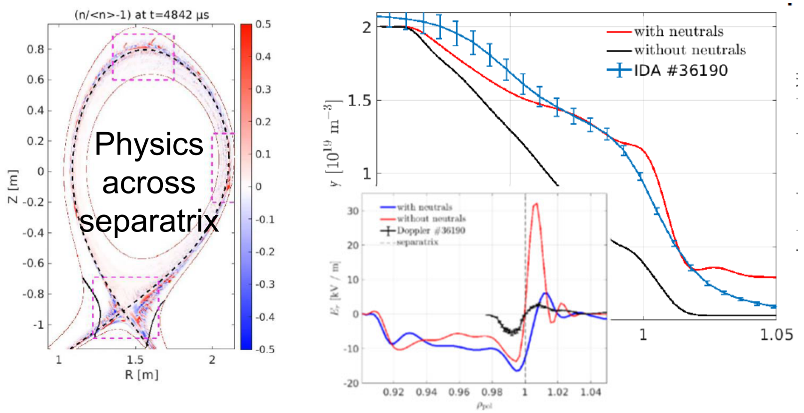
from (TH3-4, Hakin)



from (TH2-3, Xia)

4.1 structure and dynamics

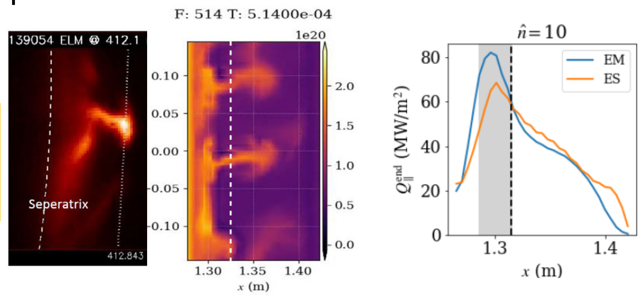
Turbulence and profile evolution across edge and SOC in AUG are studied using GRILLIX, global EM drift reduced Braginskii with neutrals. Neutral dynamics is important in predicting profiles and Er field.



TH/3-2 Zholobenko

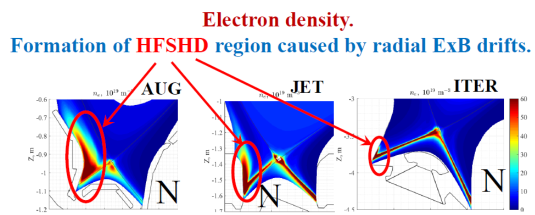
Nonlinear full-f EM continuum turbulent simulation in edge/SOC region modeling open field line with sheath condition are performed using Gkey II and blob dynamics are reproduced. EM effect increases peak heat flux while is reduced with respect to ES case.

TH/3-3 Hakim

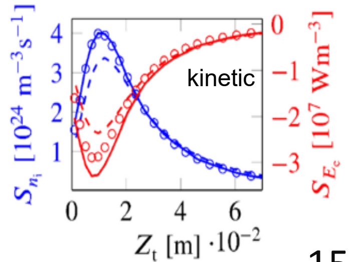


Heat flux control on W divertor for ITER using SOLPS including fluid drift. Machine dependence (AUG, JET, ITER) of the effect of drifts on divertor asymmetry, ionization dynamics and neutral confinement are systematically studied. Symmetry is increased in larger machine, preferable for ITER.

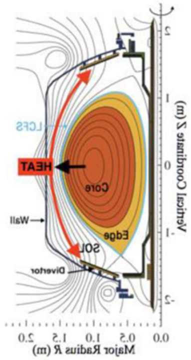
TH/3-5 Rozhansky



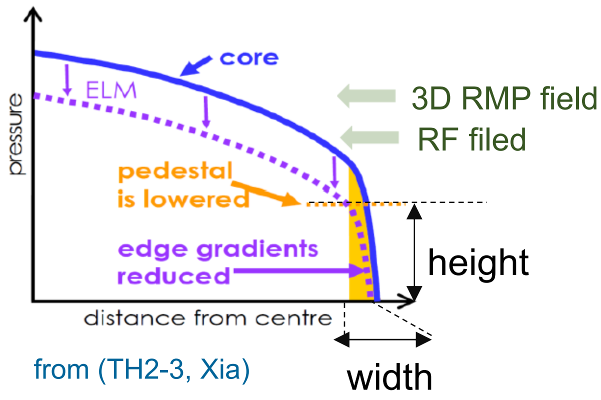
Fluid-kinetic hybrid (FKH) code for edge transport modelling with neutrals has been progressed with improved computing performance with high model accuracy approaching full kinetic simulations.



THP/2-1, Borodin



from (TH3-4, Hakin)



from (TH2-3, Xia)

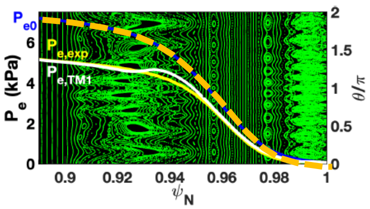
- Plasma response and penetration, leading to proper pedestal pressure degradation, e.g. ~15%
- Interaction between degraded pedestal structure and Fluctuation dynamics

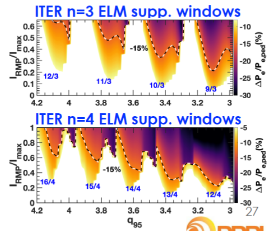
Whether EMP mitigation/suppression result from linear process or nonlinear ?

4.2 Edge/pedestal control by RMPs, RMPs …

Island formation by RMPs in DIIID/ITER using TM1 is studied, showing lower density is favorable for penetration. The pedestal top island limits height and width, while foot islands cause density pump-out. Narrow q95 window for n=3 RMP in DIIID, while wider for n=4 ITER.

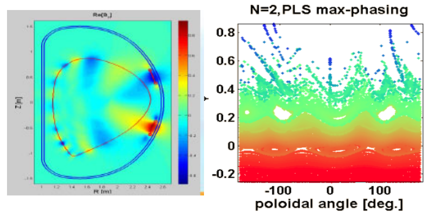
TH/2-1 Hu





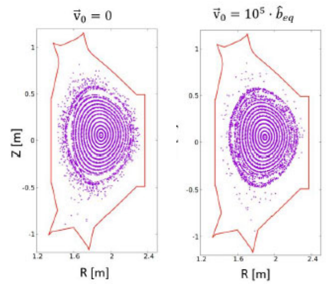
Optimal RMP coil phasing for ELM suppression, threshold coil current and favorable q_{95} window for ELM mitigation in HL-2M is studied using MARS-F. Optimum phasing causes amplifies field and island distortion, which leads to fast ion losses,

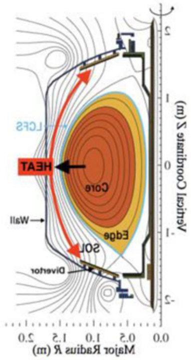
TH/2-5 Hao

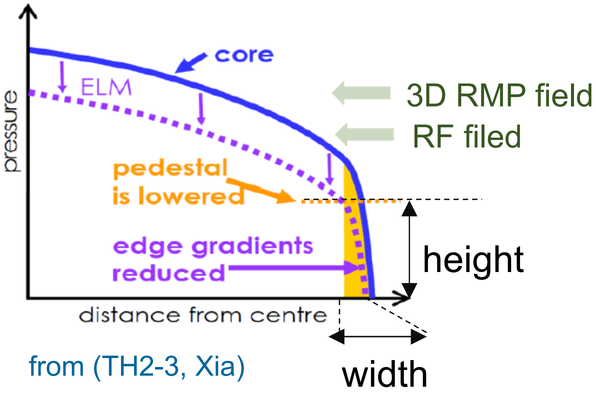


RMP penetration with self-consistent flows in EAST using HINT. RMP field partially shielded by flow leading to self-healing.

TH/P3-13, Huang



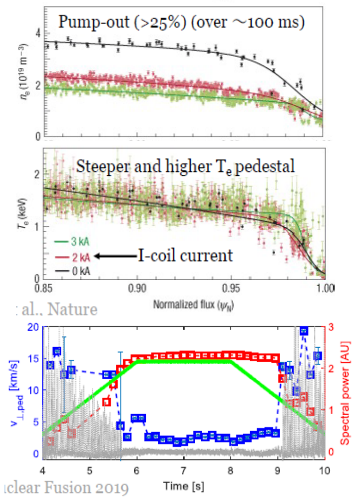




from (TH3-4, Hakin)

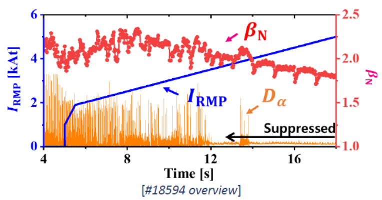
from (TH2-3, Xia)

Whether EMP mitigation/suppression result from linear process or nonlinear ?



T. Evans et al., Nature 2006

From TH/3-1 Hager



From TH/2-4 Kim

4.3 Interaction between RMP and ELM

ELM suppression in KSTAR by the synergy effect between degraded pedestal including NTV effect (density pump-out) and RMP-ELM nonlinear coupling using JOREC+PENTRC

Degraded pedestal

Driving ↓

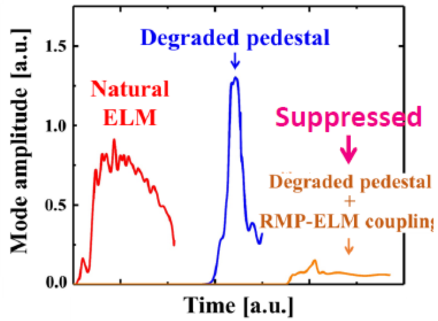
+

filament structure

Broadened spectrum

Enhanced interaction

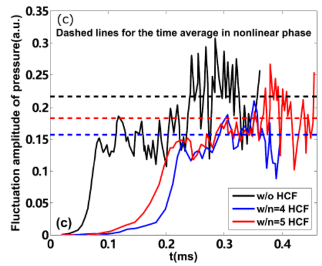
Dissipation ↑

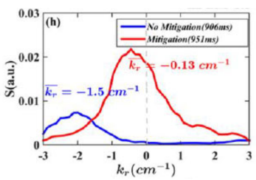


TH/2-4 Kim

RF (LHW) induced Helical Current filaments (HCF) in EAST increases turbulence, while ELM mitigation takes place, same role as PCM (pedestal coherent mode), using BOUT++.

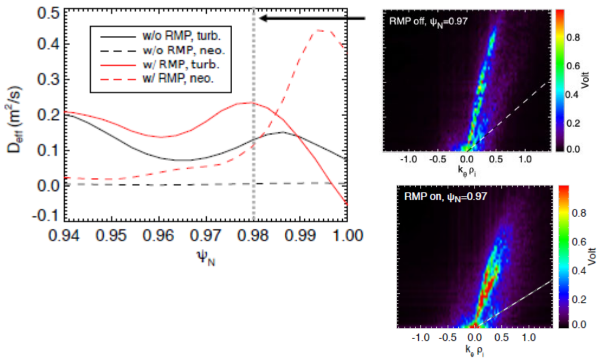
TH/2-3 Xia





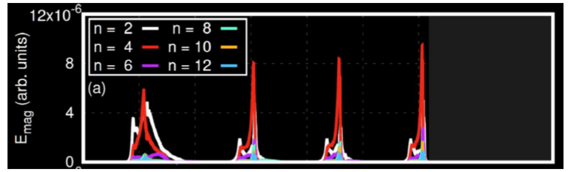
Physics of the density pump-out while steeper electron temperature (with ITB) in DIIID and KSTAR is studied, showing that density fluctuation by TEMs increases causing particle flux while electron temp. perturbation is suppresses using XGC+M3D-C1

TH/3-1 Hager



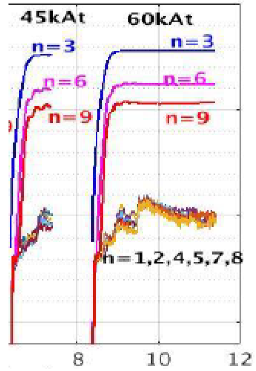
ELM and disruption dynamics are studied using JOREC, showing multiple type-I ELM cycle consistent with experiments. ELM trigger by pellet and RMP suppression are confirmed.

TH/3-3 Hoelzl

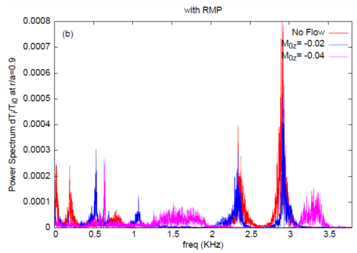


ELM suppression by RMP in ITER (15MA/5.3T) n=3 and 6 coil spectrum 45-60 kAt (Imax=90 kAt) using JOREC.

THP/3-24 Becoulet



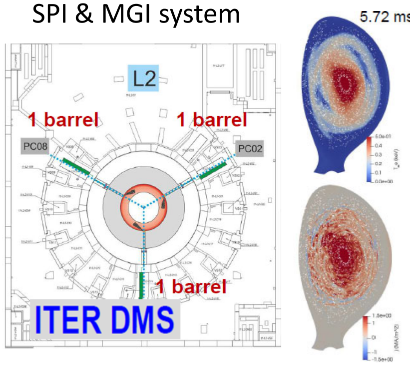
ELM cycle with toroidal flow and RMP using 2-fluid CUTIE simulating profile-turbulence interaction. Synergetic effect of countercurrent sheared toroidal flow coupled with RMP, leading to spectral spread and ELM suppression.

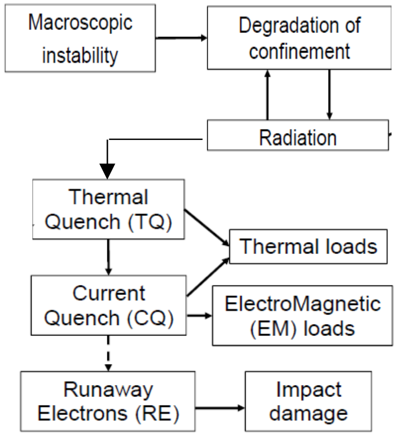


TH/2-2 Chandra

5. Disruption and RE

SPI & MGI system

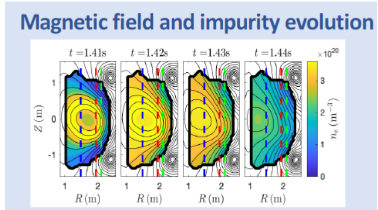




From (TH/6-1 Nardon)

RE extraction simulation using local vertical field (LVF) coil od ADITAY

TH/P1-24 Dutta



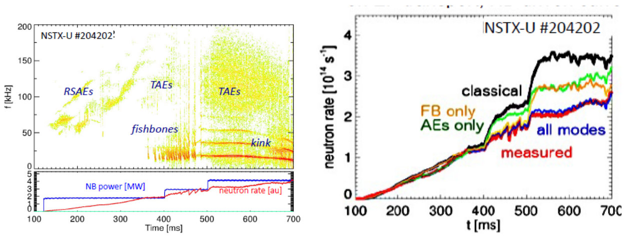
5.1 RE dissipation / mitigation

Efficient EP loss evaluation by ELM control coil phase

TH/P1-25 Sarkimaki

Transport code coupled with EP dynamics including the effect of AEs, FB, kink, tearing modes based on kick model.

TH/P1-26 Padesta



5.2 RE diagnostics methodology

Effect of high-Z impurities (from wall, antenna, also MG injection) on fast electrons (CD), screening effect of potential on collision cross-section and Blemstrahlung.

TH/P1-15 Peysson

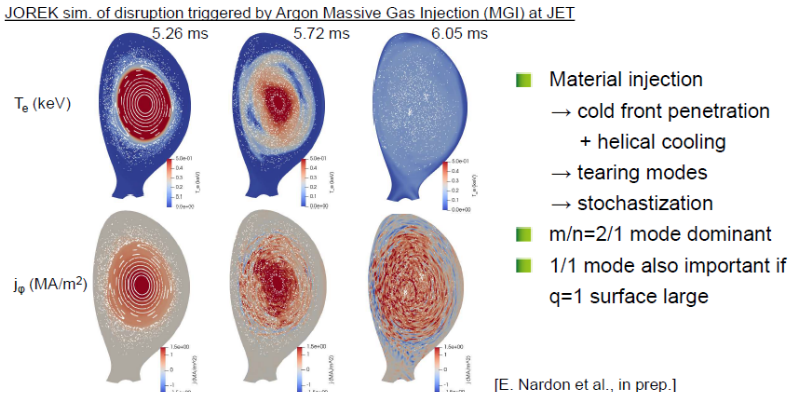
Measurement of polarization (fraction and angle) of synchrotron radiation for RE measurement in JET.

TH/P1-17 Hoppe

5.3 disruption mitigation (RE, VDE ..)

RE avoidance by 2 step H2 and Ne SPI scheme and also pellet, aiming at ITER disruption mitigation scheme (DMS)

TH/6-1, Nardon

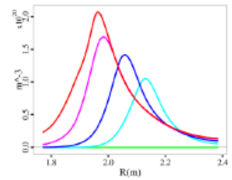


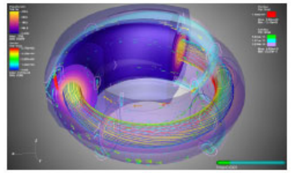
Detail comparison of SPI and MGI with different collision model using KORC, importance of accurate modelling of impurity transport with neutral

TH/P1-9, Beidler

Simulation of disruption mitigation by SPI and dispersive shell Pellet (DSP) has been progressed using NIMROD coupled with single MHD for impurity and radiation.

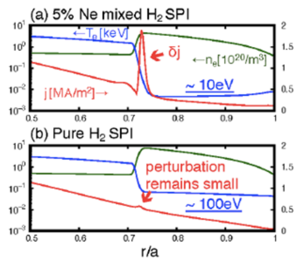
TH/P3-16 Kim





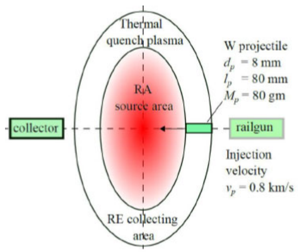
Numerical modeling of SPI in ITER DMS, which traces thousands of pellet shards in 1.5D code, INDEX, founds H2/D2 SPI is a promising scheme to avoid RE.

TH/P3-12 Matsuyama



RE mitigation using PFC (W,C,Be) projectile injection w/o MGI/SPI to the level below 1MA, which reduce the technological load after disruption.

TH/P3-9, Kuteev

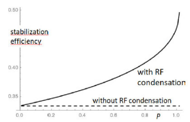


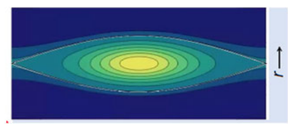
Effective RE generation and mitigation by SPI and MGI taking into account spatial transport using BMC (Backward Mocte Carli) scheme and KORC

TH/P1-30 Del-Castillo-Negrete

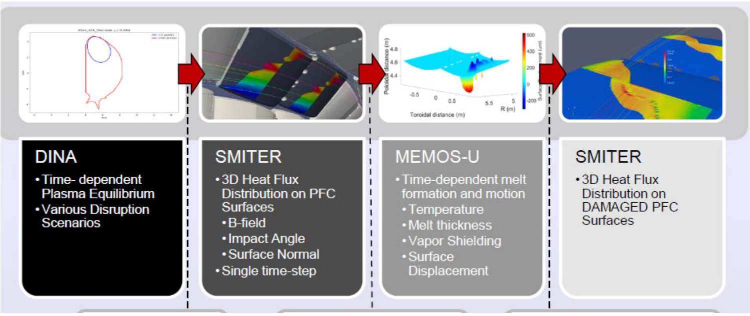
Disruption avoidance due to large island by RF current condensation

TH/P3-17, Reiman





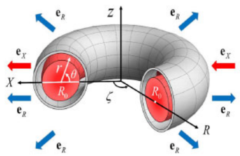
Evaluation of ITER heat load (energy deposition) and melt deformation in major disruptions and VDEs for determining realistic life time.



TH/7-3 Coburn

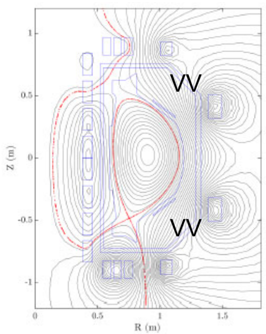
Studies of the disruption force with plasma evolving unstable (RWMs) with rotation, leading to sideway force

TH/P3-4, Pustovitov



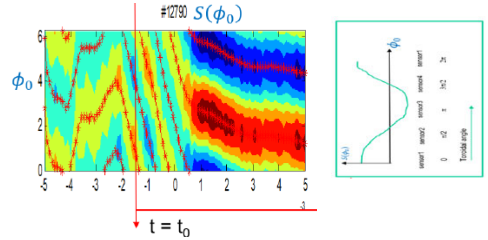
Numerical computation of disruption event in COMPASS-U with complicated coil systems with stabilizing plate inside VV, leading to 43 times larger radial force due to poloidal eddy current.

TH/P3-6, Yanovskiy



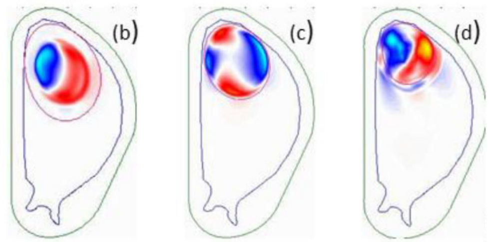
Physics model of rotating halo current, vibration modes of machine structure, during VDE, important besides eddy and halo current,

THP/3-11, Park



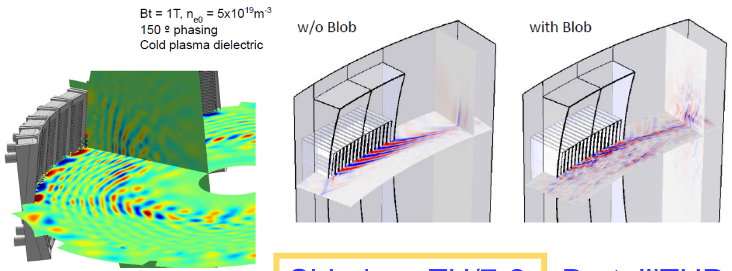
Evaluation of vessel force from VDE disruption in JET/ITRT using M3D-C1. lead to the horizontal force smaller than 1MN.

THP/3-14, Jardin



6. Heating and current drive

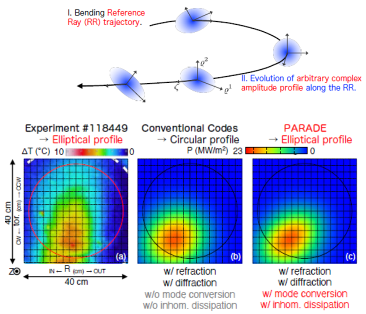
Integrated whole device scale RF modeling. Fully resolved 3D field including antenna/SOL CAD data including density perturbation modifying spectrum. Full torus NSTX HHFW.



Shiraiwa TH/7-2, BertelliTHP /2-16

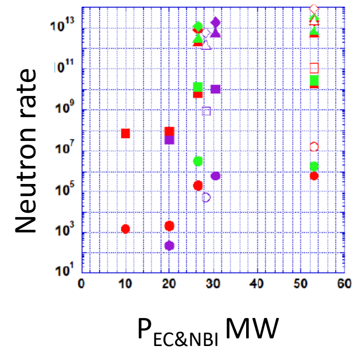
Quasi-optical ray tracing code PARADE that captures refraction, diffraction, mode conversion, and inhomogeneous dissipation, simultaneously, validated with LHD exp.

TH/P2-7
Yanagihara



7. ITER operation, others

Plasma scenarios in the ITER for a wide range of Be concentration which interacts with fast ions by various heating scheme, N-NBI, ICRH, causing fusion neutrons, taking into account of Sawtooth and AEs.



TH/P2-8 Polevoi

JINTRAC –A state-of-the-art tool for integrated modelling of the whole plasma is explored for Global Plasma Simulations for ITER Scenario Development

- The ITER Research Plan: initial power of 20MW ECRH in PFPO-1.
  - Upgrade by 10MW to 30MW ECRH for PFPO-1 under discussion.

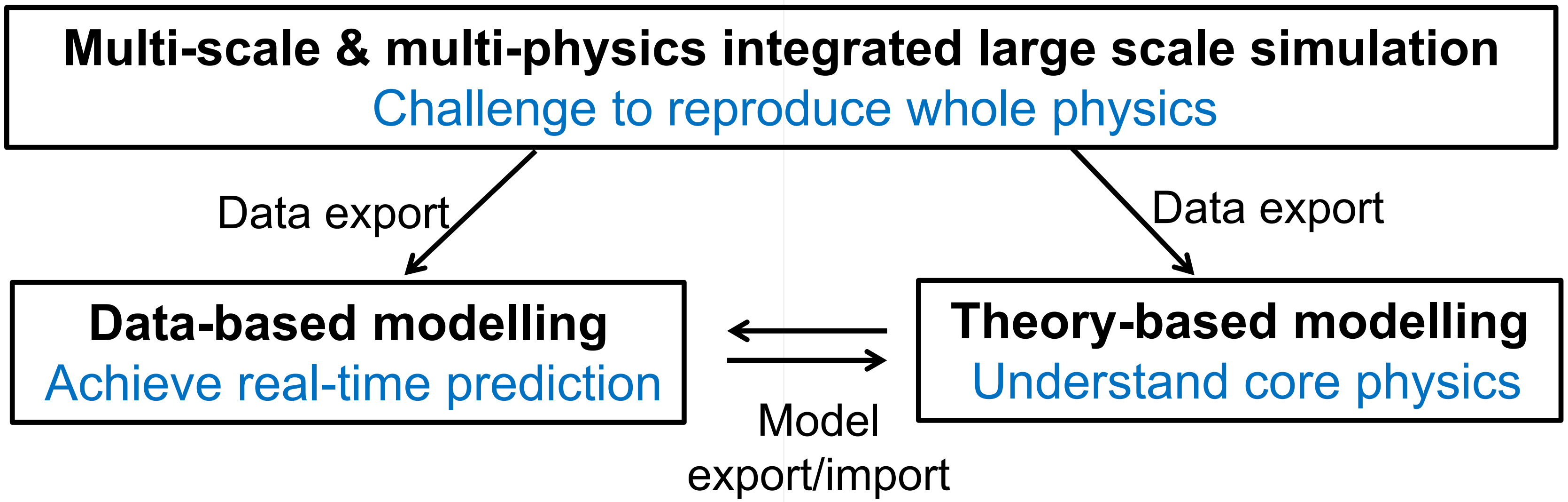
Our study support this upgrade and suggest that robust type-I ELMy H-mode operation for 5MA/1.8T H, He and H- He minority plasmas requires 30MW ECRH in PFPO-1.

- PFPO-2: Type-I ELMy H-mode operation at 7.5MA/2.65T requires:

TH/1-1 AsP

Summary

Significant progresses have been achieved in theory / simulation from last FEC2018 targeting on the ITER as an approaching goal based on three axes,



- Theory and simulation have reached a mature level that supports ITER.
- Further understandings is requested toward the start of ITER experiment.
- Organic collaboration among three axes are highly expected.