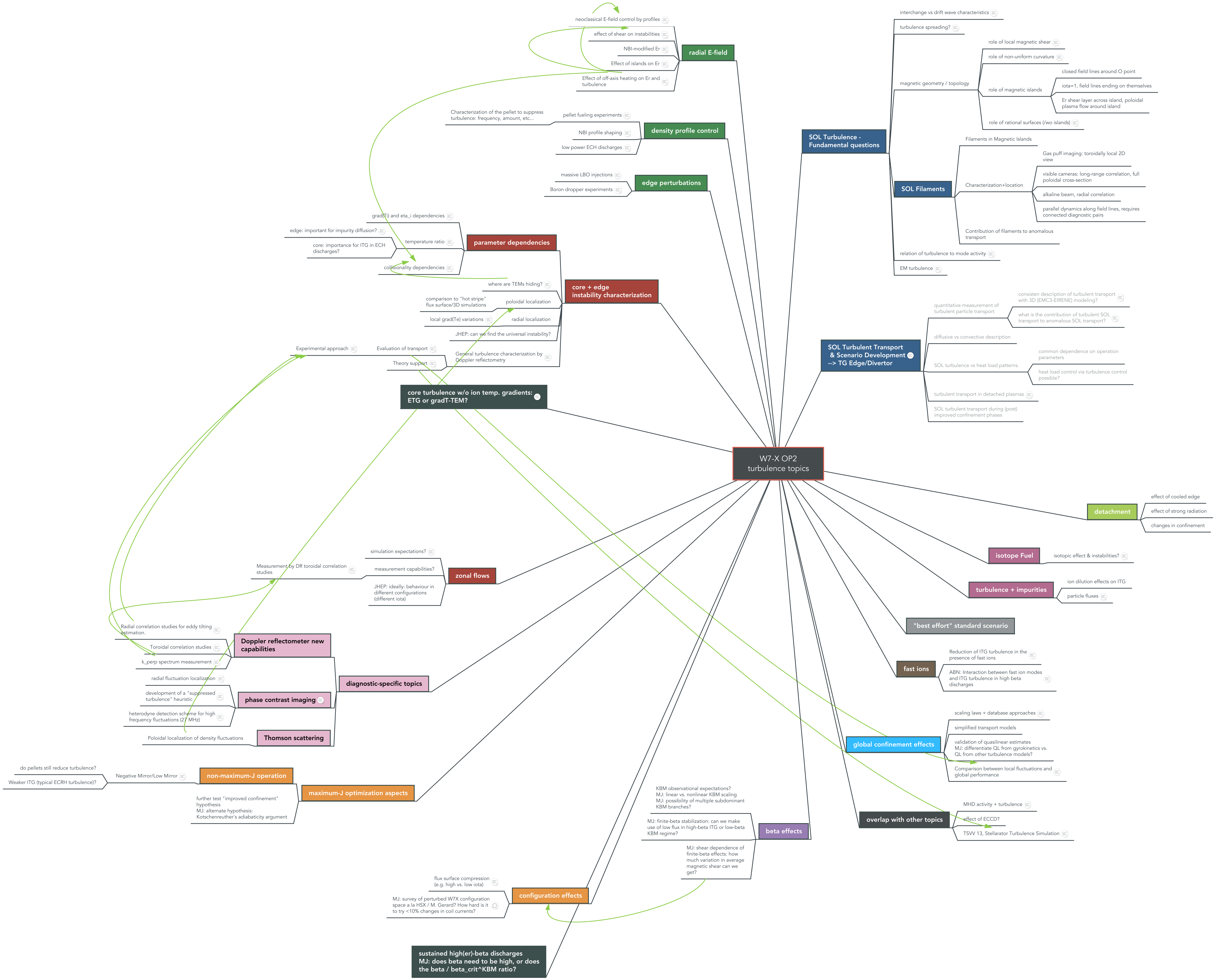

W7-X OP2 turbulence topics
radial E-field
neoclassical E-field control by profiles
effect of shear on instabilities
NBI-modified Er
Effect of islands on Er
Effect of off-axis heating on Er and turbulence
density profile control
pellet fueling experiments
Characterization of the pellet to suppress turbulence: frequency, amount, etc...
NBI profile shaping
low power ECH discharges
edge perturbations
massive LBO injections
Boron dropper experiments
parameter dependencies
grad(Ti) and eta_i dependencies
temperature ratio
edge: important for impurity diffusion?
core: importance for ITG in ECH discharges?
collisionality dependencies
core + edge instability characterization
where are TEMs hiding?
poloidal localization
comparison to "hot stripe" flux surface/3D simulations
radial localization
local grad(Te) variations
JHEP: can we find the universal instability?
General turbulence characterization by Doppler reflectometry
Evaluation of transport
Experimental approach
Theory support
core turbulence w/o ion temp. gradients: ETG or gradT-TEM?
zonal flows
simulation expectations?
measurement capabilities?
Measurement by DR toroidal correlation studies
JHEP: ideally: behaviour in different configurations (different iota)
diagnostic-specific topics
Doppler reflectometer new capabilities
Radial correlation studies for eddy tilting estimation.
Toroidal correlation studies
k_perp spectrum measurement
phase contrast imaging
radial fluctuation localization
development of a "suppressed turbulence" heuristic
heterodyne detection scheme for high frequency fluctuations (27 MHz)
Thomson scattering
Poloidal localization of density fluctuations
maximum-J optimization aspects
non-maximum-J operation
Negative Mirror/Low Mirror
do pellets still reduce turbulence?
Weaker ITG (typical ECRH turbulence)?
further test "improved confinement" hypothesis
MJ: alternate hypothesis: Kotschenreuther's adiabaticity argument
configuration effects
flux surface compression (e.g. high vs. low iota)
MJ: survey of perturbed W7X configuration space a la HSX / M. Gerard? How hard is it to try <10% changes in coil currents?
sustained high(er)-beta discharges
MJ: does beta need to be high, or does the beta / beta_crit^KBM ratio?
beta effects
KBM observational expectations?
MJ: linear vs. nonlinear KBM scaling
MJ: possibility of multiple subdominant KBM branches?
MJ: finite-beta stabilization: can we make use of low flux in high-beta ITG or low-beta KBM regime?
MJ: shear dependence of finite-beta effects: how much variation in average magnetic shear can we get?
SOL Turbulence - Fundamental questions
interchange vs drift wave characteristics
turbulence spreading?
magnetic geometry / topology
role of local magnetic shear
role of non-uniform curvature
role of magnetic islands
closed field lines around O point
iota=1, field lines ending on themselves
Er shear layer across island, poloidal plasma flow around island
role of rational surfaces (/wo islands)
SOL Filaments
Filaments in Magnetic Islands
Characterization+location
Gas puff imaging: toroidally local 2D view
visible cameras: long-range correlation, full poloidal cross-section
alkaline beam, radial correlation
parallel dynamics along field lines, requires connected diagnostic pairs
Contribution of filaments to anomalous transport
relation of turbulence to mode activity
EM turbulence
SOL Turbulent Transport & Scenario Development --> TG Edge/Divertor
quantitative measurement of turbulent particle transport
consisten description of turbulent transport with 3D (EMC3-EIRENE) modeling?
what is the contribution of turbulent SOL transport to anomalous SOL transport?
diffusive vs convective description
SOL turbulence vs heat load patterns.
common dependence on operation parameters
heat load control via turbulence control possible?
turbulent transport in detached plasmas
SOL turbulent transport during (post) improved confinement phases
detachment
effect of cooled edge
effect of strong radiation
changes in confinement
isotope Fuel
isotopic effect & instabilities?
turbulence + impurities
ion dilution effects on ITG
particle fluxes
"best effort" standard scenario
fast ions
Reduction of ITG turbulence in the presence of fast ions
ABN: Interaction between fast ion modes and ITG turbulence in high beta discharges
global confinement effects
scaling laws + database approaches
simplified transport models
validation of quasilinear estimates
MJ: differentiate QL from gyrokinetics vs. QL from other turbulence models?
Comparison between local fluctuations and global performance
overlap with other topics
MHD activity + turbulence
effect of ECCD?
TSVV 13, Stellarator Turbulence Simulation

W7-X OP2 turbulence topics

1. SOL Turbulence - Fundamental questions

1.1. interchange vs drift wave characteristics

probe data suggests interchange character in outer SOL and more drift-wave character in islands and/or close to LCFS

1.2. turbulence spreading?

caki:
- turbulence seems to be mostly local (i.e. related to local pressure gradients). Exceptions in magnetic islands.
- SOL profiles are non-monotonic especially in island divertor. Toroidal and poloidel Te and ne gradients

1.3. magnetic geometry / topology

1.3.1. role of local magnetic shear

damping of turbulence due to local magnetic shear? (e.g. at island boundaries, stochastic SOL regions)

1.3.2. role of non-uniform curvature

Brendan Shanahan's work suggests that the field line averaged curvature
determines turbulence growth --> which parallel extent to use for averaging? --> role of connection length

1.3.3. role of magnetic islands

1.3.3.1. closed field lines around O point

1.3.3.2. iota=1, field lines ending on themselves

1.3.3.3. Er shear layer across island, poloidal plasma flow around island

1.3.4. role of rational surfaces (/wo islands)

impact seen in TJ-II, associated with MHD activity at rational surfaces modifying turbulence

1.4. SOL Filaments

1.4.1. Filaments in Magnetic Islands

1.4.2. Characterization+location

1.4.2.1. Gas puff imaging: toroidally local 2D view

1.4.2.2. visible cameras: long-range correlation, full poloidal cross-section

1.4.2.3. alkaline beam, radial correlation

1.4.2.4. parallel dynamics along field lines, requires connected diagnostic pairs

1.4.3. Contribution of filaments to anomalous transport

1.5. relation of turbulence to mode activity

> 1kHz mode associated with islands, edge ~10kHz QC modes, SOL ~100kHz modes (possibly due to perturbations)

1.6. EM turbulence

> higher beta operation?

2. SOL Turbulent Transport & Scenario Development --> TG Edge/Divertor

> --> move to TG Edge & Divertor

2.1. quantitative measurement of turbulent particle transport

2.1.1. consisten description of turbulent transport with 3D (EMC3-EIRENE) modeling?

> spatially dependent diffusion coefficients

2.1.2. what is the contribution of turbulent SOL transport to anomalous SOL transport?

> e.g. role of drifts

2.2. diffusive vs convective description

2.3. SOL turbulence vs heat load patterns.

2.3.1. common dependence on operation parameters

2.3.2. heat load control via turbulence control possible?

2.4. turbulent transport in detached plasmas

probably weaker due to smaller gradients in SOL (?)
(ionization front is inside the LCFS, SOL particle balance dominated by local ionization)

2.5. SOL turbulent transport during (post) improved confinement phases

3. detachment

3.1. effect of cooled edge

3.2. effect of strong radiation

3.3. changes in confinement

4. isotope Fuel

4.1. isotopic effect & instabilities?

JA

5. turbulence + impurities

5.1. ion dilution effects on ITG

5.2. particle fluxes

JA

6. "best effort" standard scenario

7. fast ions

7.1. Reduction of ITG turbulence in the presence of fast ions

simulations by Alejandro Banon-Navarro

7.2. ABN: Interaction between fast ion modes and ITG turbulence in high beta discharges

simulations by Alejandro Banon-Navarro

8. global confinement effects

8.1. scaling laws + database approaches

G. Fuchert did some nice work on this for IAEA21

8.2. simplified transport models

8.3. validation of quasilinear estimates MJ: differentiate QL from gyrokinetics vs. QL from other turbulence models?

8.4. Comparison between local fluctuations and global performance

In OP1, evidence has been found by the DR linking the amplitude of core fluctuations to global confinement parameters such as tau_E (Carralero, EPS, 2021). This comparison can be greatly refined by the enhanced diagnostic capabilities and the detailed comparison to codes which they will enable.

9. overlap with other topics

9.1. MHD activity + turbulence

astechow:
narrowband fluctuations observed by PCI in many experimental situations - large overlap with MHD group

9.2. effect of ECCD?

9.3. TSVV 13, Stellarator Turbulence Simulation

The comparison of the results of gyrokinetic simulations with the measurements of the DR system will contribute to the validation of stellarator gyrokinetic codes, one of the main goals of TSVV 13.

10. beta effects

10.1. KBM observational expectations? MJ: linear vs. nonlinear KBM scaling MJ: possibility of multiple subdominant KBM branches?

10.2. MJ: finite-beta stabilization: can we make use of low flux in high-beta ITG or low-beta KBM regime?

10.3. MJ: shear dependence of finite-beta effects: how much variation in average magnetic shear can we get?

11. configuration effects

11.1. flux surface compression (e.g. high vs. low iota)

astechow:
There were proposals

11.2. MJ: survey of perturbed W7X configuration space a la HSX / M. Gerard? How hard is it to try <10% changes in coil currents?

May 04, 2021 09:13

Anonymous said

> JHEP: do that for both ITG and TEM (i.e. the linear simulations)

12. sustained high(er)-beta discharges MJ: does beta need to be high, or does the beta / beta_crit^KBM ratio?

13. maximum-J optimization aspects

13.1. non-maximum-J operation

13.1.1. Negative Mirror/Low Mirror

> Jorge

13.1.1.1. do pellets still reduce turbulence?

13.1.1.2. Weaker ITG (typical ECRH turbulence)?

13.2. further test "improved confinement" hypothesis MJ: alternate hypothesis: Kotschenreuther's adiabaticity argument

14. diagnostic-specific topics

14.1. Doppler reflectometer new capabilities

14.1.1. Radial correlation studies for eddy tilting estimation.

> Daniel Carralero worked on that.
>
> Once the new QMRE system is online.

14.1.2. Toroidal correlation studies

> Between the current QMRV1 and the refurbished QMRV2 DR systems (the second should be operational in OP2)

14.1.3. k_perp spectrum measurement

> Newly installed steerable mirrors will allow for the measurement of fluctuation amplitude and perpendicular rotation velocity at different k_perp values.

14.2. phase contrast imaging

astechow

14.2.1. radial fluctuation localization

astechow

14.2.2. development of a "suppressed turbulence" heuristic

astechow

14.2.3. heterodyne detection scheme for high frequency fluctuations (27 MHz)

astechow

14.3. Thomson scattering

14.3.1. Poloidal localization of density fluctuations

15. zonal flows

15.1. simulation expectations?

astechow:
do we have expectations on frequencies and magnitude?

15.2. measurement capabilities?

15.2.1. Measurement by DR toroidal correlation studies

ZFs can be detected by Doppler reflectometry by investigating the modulation of the correlation level between QMRV1 and (newly operational in OP2) QMRV2 flow measurements. As well, GK simulations may be carried out in order to determine expected amplitude and frequency and to compare to experimental measurements.

15.3. JHEP: ideally: behaviour in different configurations (different iota)

16. core turbulence w/o ion temp. gradients: ETG or gradT-TEM?

Gavin, JP Bahner, Jorge

17. core + edge instability characterization

17.1. parameter dependencies

17.1.1. grad(Ti) and eta_i dependencies

Daniel:
An ITG-like relation between ion-scale fluctuations and eta_i=Ln/LTi has been found under a range of operational scenarios. Reduction of fluctuations associated to low eta_i values linked to improved global confinement.

17.1.2. temperature ratio

astechow

17.1.2.1. edge: important for impurity diffusion?

astechow:
used as argument for LBO impurity transport simulations

17.1.2.2. core: importance for ITG in ECH discharges?

17.1.3. collisionality dependencies

astechow:
G. Weir did some work on this

daniel:
As well, ion-scale turbulence suppression has been reported by the DR for low collisionality scenarios (Carralero et al. submitted to NF 2021)

17.2. where are TEMs hiding?

astechow:
do we have clear evidence of TEMs? how can we get that?

17.3. poloidal localization

17.3.1. comparison to "hot stripe" flux surface/3D simulations

17.4. radial localization

17.4.1. local grad(Te) variations

astechow:
G. Weir did good measurements in OP1.2b, continue these?

17.5. JHEP: can we find the universal instability?

17.6. General turbulence characterization by Doppler reflectometry

The characterization of turbulence carried out in OP1 was substantially limited by the fixed launching angle of the Doppler reflectometer, which restricted measurements to a single point in the $k_\perp$ spectrum. In OP2, the new capabilities of the DR system should be used to provide a complete characterization of the different regimes of turbulence, including measurements of the whole $k_\perp$ spectrum and radial correlation properties of at different radii.

17.6.1. Evaluation of transport

The proposed measurements should be sufficiently detailed to carry out quantitative comparisons with gyrokinetic simulations in order to discuss the turbulent modes driving the observed fluctuations and to evaluate the subsequent turbulent transport. As well, local measurements of turbulence can be compared to surface-averaged turbulent heat flux estimated from PB analysis.

17.6.1.1. Experimental approach

Frequency/mirror angle scans can be carried out with several Doppler reflectometer systems to cover a wide radial region in which k_perp spectra of density fluctuations is measured. As well, newly installed QMRE system can be used to provide additional information regarding eddy tilting different radii of the elliptical section. Ideally, these scenarios would be run under different magnetic configurations.

17.6.2. Theory support

Non-linear gyrokinetic simulations can be carried out for the most prominent scenarios to determine, among other relevant quantities and features: the fluctuation amplitude, the $k_\perp$ spectra of the fluctuations and the spatial localization of turbulence.

18. edge perturbations

18.1. massive LBO injections

astechow
started in OP1.2: "cold pulses" and partial detachment by LBO seems to improve confinement

18.2. Boron dropper experiments

astechow
available in OP2?
caki: will be available in OP2 as user of MPM (no dedicated boron dropper system)

19. density profile control

19.1. pellet fueling experiments

astechow

19.1.1. Characterization of the pellet to suppress turbulence: frequency, amount, etc...

19.2. NBI profile shaping

astechow:
more pure-NBI experiments needed for proper characterization!

19.3. low power ECH discharges

astechow
seem to show "rounder" density profiles in OP1

20. radial E-field

20.1. neoclassical E-field control by profiles

idea by F. Reimold

20.2. effect of shear on instabilities

astechow
can we control shear somewhat?

Strong correlation between Er shear and turbulence suppression has been reported in HP discharges by the DR (Estrada NF 2021)

20.3. NBI-modified Er

astechow

20.4. Effect of islands on Er

During OP1, the strong effect of islands on both radial electric field and fluctuations has been demonstrated by Doppler reflectometry inside the LCFS (Estrada, to be submitted to NF 2021). However, the number of discharges featuring limiter configurations and within the density range accessible to the DR is still very limited. An improved characterization of the impact of island effect is still pending and would greatly benefit from the new diagnostic capabilities of the OP2 DR system.

20.5. Effect of off-axis heating on Er and turbulence

Off-axis heating, both by means of ECRH and NBI, may lead to broader temperature profiles and thus lower collisionalities at the region of DR measurement. According to NC theory, the Er fields (and their shear) are expected to change in the edge region of the confined plasma. This could represent a relatively controlled
manner (differently to what happens in high performance scenarios) to increase the magnitude of the velocity shear, potentially leading to a suppression of fluctuations and turbulent transport. As well, this radial increase of the low collisionality region would represent a good method to test the ITG to TEM transition hypothesis, by evaluating if the region of low fluctuations at the core extends similarly towards the edge.