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Core transport and confinement in multi-ion plasmas

Overview of the status of Joint Experiments and Joint Actions

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Introduction

In this session, we will review the status of the TC - Core transport and confinement in multi-ion plasmas PWG.

- Overview of the status of Joint Experiments & Joint Actions — D. Carralero/M. Nunami
- Review of prominent experimental results from 2024-2025
  - Status of W7-X/LHD comparative studies and plans for the upcoming LHD campaign — K. Tanaka
  - Summary of EM turbulence studies in the OP2.2 and OP2.3 campaigns in W7-X — K. Aleinikova
  - Overview of the impurity injection studies and remaining work for LHD — F. Nespoli
- Review of prominent simulation results from 2024-2025
  - Validation of the GENE-Tango-KNOSOS suite in W7-X — D. Fernando
  - Transport studies with stella: evaluation of massive parametric scans with TJ-II and W7-X data — J.M. García-Regaña
  - Emergence of sub-theshold KBMs in W7-X high beta plasmas — P. Mulholland
- Discussion

Overview of the status of Joint Experiments

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Proponent	Title of the proposal	Medium-term deliverable of the JE	Short term Goal	List of devices involved in the JE	Proposed coordinator/ working team
Nespoli/ Tamura	Confinement improvement via powder injection - cross machine comparison	Compare confinement improvement and turbulence reduction resulting from powder/TESPEL injection in similar plasma scenarios, to advance physics understanding of the phenomena. Determine maximum ammount of impurities required & tolerated by stellarator reactor.	-Compare the effect of powder injection in "identical" discharges in W7-X and LHD -Propose experiments in spring 2024 LHD campaign to mimic PMPI injector in W7-X. -Compare TESPEL/powder injections/LBO. In particular, micropellet TESPEL in TJ-II.	W7X, LHD, TJ-II	W7X: F. Nespoli, T. Wegner LHD: N. Tamura, N. Ashikawa TJ-II: A. Castro, K. McCarthy HSX : B. Geiger (LBO?)
Dinklage/ Suzuki	Similarity studies in stellarators and validation of scaling laws	Validation of scaling models based on non-dimensional parameters (rho*, nu*, beta)	-Comparison of existing data of dimensionally similar scenarios in LHD, TJ-II, H-J. -Definition of common scenario with similar parameters to be conducted in at least LHD and W7-X, plus any number of the smaller machines. -Conduction of related experiments in OP2.2 campaign in W7-X.	W7X, LHD, TJ-II, H-J	LHD: Y. Suzuki W7X: A. Dinklage, B. Hjördis TJ-II: A. Alonso H-J: Inagaki
Panadero	Study of plasmoid drift and magnetic configurations	Creation of standarized database of deposition measurements to be used to validate HPI2 code.	-Definition of common data formats -Identification of gaps in existing data and proposal of experiments.	W7X, LHD, TJ-II, H-J	TJ-II: N. Panadero LHD: R.Sakamoto, G. Motojima H-J: G. Motojima, S. Kado W7X: Jürgen Balzuhn, K. Hammond
Tamura	Optimization of core particle ratio (H/D, H/He, D/He, H/D/He) control method by edge fueling/exhausting in stellarators	Comprehensive knowledge base for controlling particle ratios, which provides information to reference stellarator reactor design points (profile, size?)	-Collect data on isotope ratios in W7X -Discuss methos to control profiles. - Assess conductability in TJ-II and H-J	W7X, LHD, TJ-II, H-J	LHD: N. Tamura W7X: F. Reimold (O.Ford, T. Romba) TJ-II: K. McCarthy H-J: S. Kado
Dinklage	Safe plasma operation: plasma termination in thermal quenches	Characterization of mechnanism in thermal quenches in stellarators and proposals for potential mitigation measures	-Start comparison between existing data in W7X and LHD -Carry out new experiments in OP2.2 campaign for W7-X, fall 2023 campaign in TJ-II.	W7X, LHD, TJ-II	W7X: A. Dinklage, B. Hjördis, D. Najouks. TJ-II: K. McCarthy, D. Medina LHD: N. Tamura
Aleynikova	Comparative analysis of EM instabilities	General characterization of the onset of EM turbulence in stellarators, with particular emphasys on resistivity and shear, as a first step for the validation of theoretical models and investigation of implications on transport and confinement.	- Conduct a systematic study of W7-X plasmas stability with respect to EM modes by varying magnetic configurations with different shear and conducting resistivity scans: An experiment has been proposed for OP2.2/2.3 with this aim. - Comparison of W7-X results with equivalent LHD and HSX scenarios	W7X, LHD, HSX	W7X: K. Aleynikova, J. Geiger, C. Bueschel , D. Carralero LHD: Y. Suzuki, T. Kobayashi HSX: B. Geiger

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Y. Suzuki: No significant progress. Study of SDC plasmas in LHD and H-J ongoing.

Effect of Impurities on Stellarator Performance

Main actions carried out/results obtained since the 23rd CWGM (May 2023):

- LHD: Experiments proposed and performed, boron (B) powder injected 4 scenarios:
  - LHD1- F Warmer PRL 2021 style (comparison with W7-X)
  - LHD2- R Lunsford PoP 2021 style (W7-X comp)
  - LHD3- a perpendicular NBI only scenario (W7-X comp)
  - LHD4- very low density and power scenario (Comparison with TJ-II and/or HSX)
- TJ-II: B_4C powder injection experiment attempted using the TESPEL mechanism. Only a few shots available before powder got stuck in the mechanism. LBO experiments were performed with B target, no clear effect on plasma.
- W7-X: experiments proposed and performed in OP2.3, injecting B4C in pulses with PMPI in three scenarios:
  - W7X1 – equivalent to LHD1
  - W7X2 – equivalent to LHD2
  - W7X3 - NBI +ECH : biggest effect on confinement and turbulence
- B LBO compared to PMPI for all 3 scenarios: no clear effect from LBO (too little material injected?)

Effect of Impurities on Stellarator Performance

Next steps to be taken:

- Progress with analysis of LHD, W7-X and TJ-II experiments
- Perform further LHD experiments for direct comparison to scenario W7X3
- Install a small impurity powder dropper on TJ-II. Paperwork ongoing
- Perform B LBO experiments in HSX. Install small IPD on HSX

Results to be achieved in short term (next 12 months):

- Comparison of LHD and W7-X powder injection experiments results
- Comparison of LBO experiment results on TJ-II and HSX, W7-X
- Comparison of powder injection and LBO experiments on W7-X
- Publish

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Study of plasmoid drift and magnetic configurations

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Main actions carried out/results obtained since the 23rd CWGM (May 2023):

- Experiments in OP2.2 and OP2.3 were conducted with the new CPFS, allowing for the study of dependences on the magnetic configuration
- Analysis of some pending data from TJ-II
- Oral presentation on the effects of magnetic configuration on pellet fuelling in TJ-II and W7-X at the upcoming 51st EPS Conference

Next steps to be taken:

- Meeting after EPS and before last LHD campaign → split work to fill in database.
- Proposal for the 26th LHD campaign
- Find other codes for benchmarking?

Results to be achieved in short term (next 12 months):

- Select representative cases from each device and run simulations
- Prepare proposals to address any gaps in the data
- Start preparing a paper comparing the pellet fuelling across the four machines

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Status of JE: Comparative analysis of plasma resistivity and shear effects in stellarator high beta plasmas

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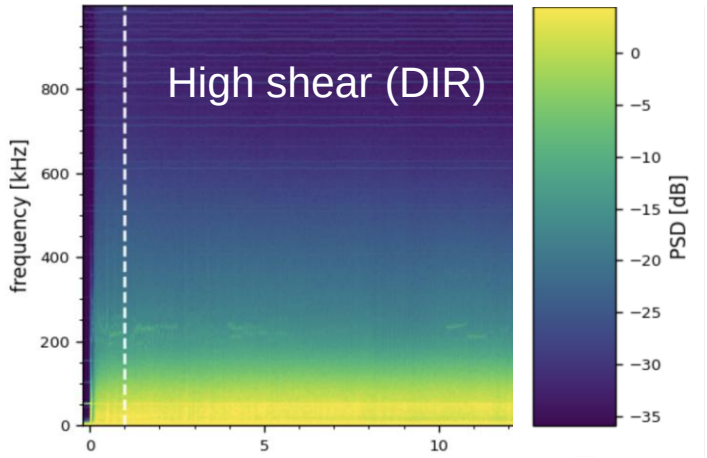
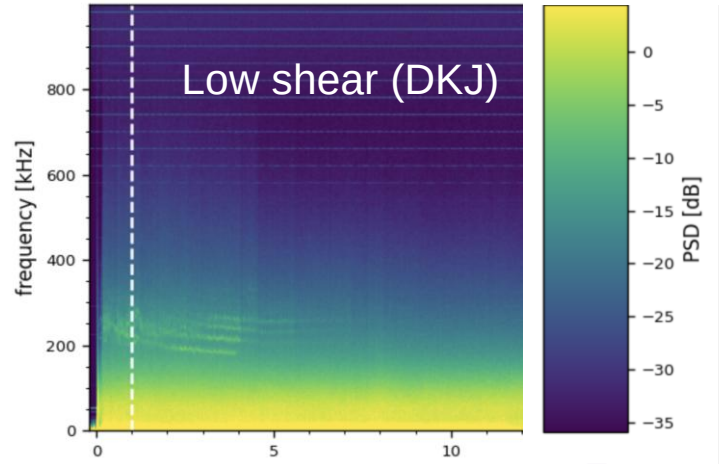
Main actions carried out/results obtained since the 23rd CWGM (May 2023):

- Conducted successful W7-X OP2.3 sessions in both low- and high-shear configurations
- Acquired comparison shots in standard configuration during contingency weeks
- Observed preliminary ITG mode stabilization with increased shear
- Indications of KBM stabilization (tentative due to pellet issues)
- Obtained good low-power/low-density discharges for cross-device comparison



Next steps to be taken:

- Analyze W7-X data across configurations
- Obtain and analyze low-beta data from LHD
- Finalize LHD equilibrium studies (numerical) for informed proposal submission



Results to be achieved in short term (next 12 months):

- Comparative assessment of shear effects on ITG/KBM stability in W7-X and LHD
- Proposal submission and experimental planning for KBM studies in LHD

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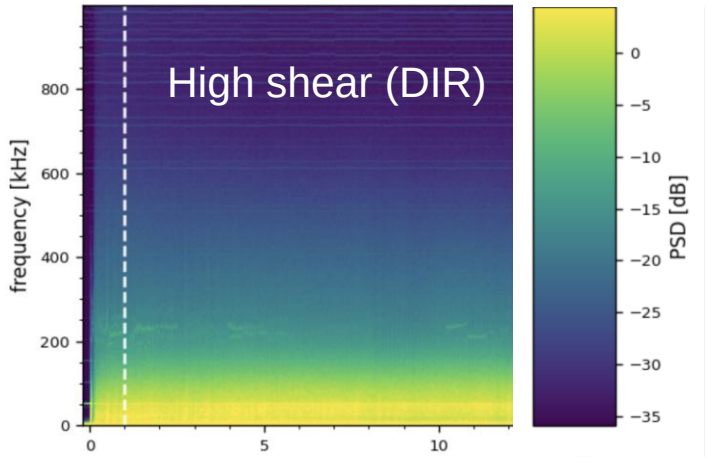

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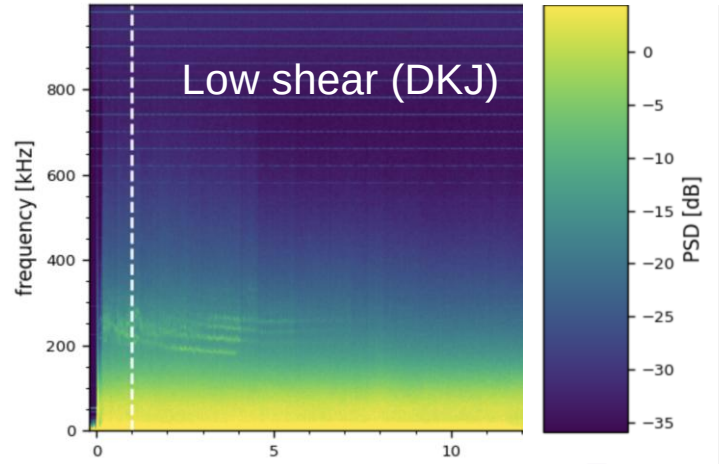

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