

14th Coordinated Working Group Meeting Warsaw, 16-19 June 2015

The 14th Coordinated Working Group Meeting (CWGM14) was held from 16 to 19, June 2015 at the Golden Tulip Warsaw Center, hosted by the Institute of Plasma Physics and Laser Microfusion (IPPLM, <http://www.ipplm.pl/en/>). This was the first CWGM in Poland, reflecting by the expanded coordinated collaborations based on EUROfusion, mission 8: Stellarator. The IPPLM has been especially known through its cutting-edge diagnostics development. Thus, a dedicated diagnostics session was held this time, to stimulate international collaborations on diagnostics development and applications. Impurity transport session will become the standing session, as suggested and agreed in the Stellarator-Heliotron Strategy Workshop, Nagoya, March 2015 (cf., Stellarator News, No.147, April 2015). C.Hidalgo (CIEMAT) provided a kick-off talk remotely to raise critical issues in impurity transport.

Below, session summaries and formulated action lists are described. The presentation materials will be posted on the EUROfusion wiki page, soon or later.

Session summaries

Strategic Collaboration (A.Dinklage / F.Warmer)

- The EUROfusion Mission 8 activities focus on the exploitation of W7-X and actions to prepare a physics basis for a HELIAS Fusion Power Plant (FPP),
- International collaborations within the work package objectives can be supported by missions (mobility) and resources (within the WPS1 activities) – IEA Stellarator-Heliotron Implementing Agreement has proven to be the right frame for joint actions
- The CWGM is proposed to be a frame to prepare further input to strategic discussions towards reactor issues
 - Common systems assessments
 - Clarification of ‘road map’ targets
- LHD (M.Yokoyama) is setting up TASK3D-a to provide confinement and profile data on a regular basis
- Update of confinement database with HSX data,
- interim responsible officer has been identified: F.Warmer (IPP-Greifswald), <https://ishpdb.ipp-hgw.mpg.de/ISHPDB/public/>

Alfvén Eigenmodes (AEs) and Energetic Particles (S.Yamamoto)

We mainly discussed what we should investigate of AEs aiming at stellarator/heliotron DEMO.

- Effect of ECH/ECCD on AEs for control of AEs
 - TJ-II : “Impact of ECRH on the NBI-driven Alfvén activity in the TJ-II stellarator: experiments and data analysis” by Á.Cappa
 - Heliotron J : “External Control of Energetic-ion-driven MHD instabilities by ECH/ECCD in Heliotron J Plasmas” by S.Yamamoto
- Fast ion generation by ICRF, “Fast-ion generation with ICRF at Wendelstein 7-X in high-density regimes” by Y.Kazakov

Experiment (S.Masuzaki)

- Status of Uragan 2M was presented by V.Moiseenko: Dedicated RF conditioning study has been conducted. Stellarator with embedded mirror configuration has been examined both experimentally and numerically. It is for the Stellarator-Mirror hybrid device for the fusion-fission hybrid device.
- Status of the development of 3D fluid code “Findif” for edge plasma modeling was presented by G.Pelka. Findif was applied to the edge plasma modeling in the TEXTOR DED and W7-X, respectively. Benchmark is necessary.
- S.Kumar presented the flow and electric field study in HSX. They are measured by using Pfirsch-Schlüter flows, and using MSE polarimetry. Measured field is compared to the numerical simulation data with PENTA code. It is larger than the numerically expected values near the core. Benchmarking the E_r calculated by SFINCS and FORTEC-3D to the PENTA results is underway.

Impurities and Transport (N. Tamura)

- Kick-off for the new standing session: C.Hidalgo brought up important issues related to the impurity control. Question to be answered: “Optimum profiles for achieving high fusion gain without impurity accumulation (high & low Z) in Stellarator-Heliotron plasmas?”
- LHD: Existence of the impurity transport boundary layer inside the LCFS is suggested, which alter the accumulation of core-born impurity

- HSX: Laser blow-off (LBO) + 5 photodiode arrays are ready for the impurity transport study in HSX, and the collaborations (e.g. LBO system, STRAHL analysis) are highly welcome
- Uragan 2M/Uragan 3M: U-2M suffers from the impurities from the wall, and U-3M indicated the possibility of the control of impurities by the RF heating

Theory/Simulation

- Importance of parallel inertia force, which can cause impurity density variations in stellarator/heliotron plasmas, was highlighted
- Neoclassical-based impurity transport problem, such as a potential fluctuation on flux surface, etc. is being numerically (EUTERPE, FORTEC-3D, ...) analysed

Diagnostics (M.Kubkowska)

- W7-X: Limiter diagnostics: visible cameras and a low-resolution near infrared (NIR) camera for plasma monitoring, wall inspection and thermography, higher-resolution camera for scrape-off layer physics, set of Langmuir probes; pulse height analysis (PHA) system; light impurities monitor (for Carbon and Oxygen monitor) have been presented
- The following LHD diagnostics systems have been described:
 - Density and temperature, radial electric field and rotational transform profiles: YAG Thomson scattering, Far Infrared (FIR) and CO₂ interferometer, change exchange spectroscopy (CXS), heavy ion beam probe (HIBP), motional Stark effect (MSE)
 - Impurity: Infrared (IR) imaging bolometer, vacuum-ultraviolet (VUV) spectrometer, extreme-ultraviolet (EUV) spectrometer, change exchange spectroscopy (CXS)
 - turbulence: HIBP, phase contrast imaging (PCI), microwave frequency comb reflectometer, correlation electron cyclotron emission (CECE), beam emission spectroscopy (BES)
- For Heliotron J: Thomson scattering, CXS based on Czerny–Turner spectrometer, Langmuir probe, BES, 60-channels soft X-ray system and fast ion diagnostics have been listed and described.
- In the PHA system for W7-X - Si drift detectors will be used at the beginning - SiC or other detectors could be considered as a candidate for Deuterium campaign - tests at LHD during the Deuterium campaign possible?
- Application of gas electron multiplier (GEM) detectors for soft X-ray measurements with

energy discrimination capability has been presented. This kind of detectors could be interesting for W7-X diagnostics.

- Scintillators for Gama-ray diagnostics have been detailed presented.

Fuelling and Particle Transport (K.McCarthy)

- 4 talks showing growing collaborations on pellet injection experiments and particle transport issues between LHD, W7-X and TJ-II
- Review of need to find means of avoiding hollow density profiles in stellarators that can lead to discharge termination (core pellet fueling, role of radial electric field, transport, need to be considered in detail).
- Reports on pellet injection systems and recent upgrades on LHD and TJ-II with capabilities and limitations of each system.
- Reports on pellet fueling experiments conducted on LHD and TJ-II that will provide input for presentation at the coming ISHW.
- Reports on data analysis by S.Cats and J.-L.Velasco (somewhat preliminary still) should be completed by ISHW.
- Discussion on pellet interaction in the different plasmas and on additional data that should be considered for analysis (e.g. plasma pressure in TJ-II, neutral beam particles, etc.).

Action List

Strategic Collaboration (A.Dinklage / F.Warmer)

- Research issues for τ_E documentation
 - Assess global scaling of HSX data
 - Renormalization factor, f_{ren} in the ISS04 (International Scaling) for LHD updates, HSX
 - Assess impact of plasma size (minor radius)
 - TJ-II NBI data to be provided
 - Joint paper on configuration effects?
- Update of profile database for code validation purposes

Alfvén Eigenmodes and Energetic Particles

(S.Yamamoto)

Short term:

- Effect of ECH/ECCD on AEs for control of AEs: LHD, TJ-II, Heliotron J
 - should apply same method, target on similar mode for getting unified knowledge
 - link to ITPA-EP (energetic particles) group, by S.Yamamoto and K.Nagaoka

Long term:

- Identification and parameter dependence of observed modes (excited by ions)

- high magnetic shear: LHD [EGAM, BAE, EPM, GAE/RSAE, TAE, HAE]: K.Ogawa, K.Nagaoka
- low magnetic shear, low iota, Heliotron J [BAE?, EPM, GAE]: S.Yamamoto
- low magnetic shear, high iota, TJ-II [GAE, HAE]: Á.Cappa, A.V.Melnikov, B.J.Sun
- Loss mechanism of fast ions caused by AEs using lost-ion probe (LIP)/fast ion loss detector (FILD)
 - LHD, CHS, Heliotron J (currently Japanese domestic collaboration/joint experiment) : S.Yamamoto, K.Ogawa
- Prediction of AEs and their effect on a particle for stellarator/heliotron DEMO
 - Experiment: parameter dependence of observed AEs such as observation region consisted of dimensionless parameters
 - Simulation: development of numerical codes for the prediction of AEs in the DEMO (need collaboration with D.A.Spong, Y.Todo, A.Könies,,)

determine how fueled particle/impurity confinement might be related.

- For ISHW presentation, K.McCarthy will need to know internal deadline in the LHD Experiment Group, and also need to consider EUROfusion deadline.
- Consider possibility for joint paper on pellet injection comparisons on LHD and TJ-II (after ISHW)

Agata Czarnecka (IPPLM) and Arturo Alonso (CIEMAT) on behalf of all participants in the 14th CWGM.

Impurities and Transport (N. Tamura)

Short term

- Experiment: formulation of joint experiments
 - Re-survey & Re-characterization of heating effects on the impurity accumulation (LHD, W7-X, TJ-II, Heliotron J, HSX, Uragan-2M/3M)
 - Turbulence characterization focusing on the impurity transport (LHD, W7-X, TJ-II, Heliotron J, HSX)
- Theory/Simulation: Feasibility study of a joint paper regarding a non-uniform potential and density on flux surface to IAEA-FEC2016 (Kyoto)

Long term

- Experiment: Acquirement of an optimized heating scheme (power, deposition location) for the suppression of impurity accumulation
- Ensuring the compatibility between a power exhaust scenario (detachment) and an impurity handling scenario
- Theory/Simulation: Strategy of the impurity code validation (improvement in prediction accuracy)
- Production of an optimum profile from the viewpoint of impurity transport

Fuelling and Particle Transport (K.McCarthy)

- It was suggested that we perform simultaneous pellet/impurity injection experiments to