Summary: Joint Working Session of SEWGs "Material Migration" and "ITER Material Mix" on Model Validation, Tervaniemi, Finland, 31.1–2.2.2011
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Significant progress in modelling reactor-relevant PWI issues

Summary

On 31 January – 2 February, 32 experts of plasma-wall interaction and edge plasma physics gathered in Tervaniemi, Finland, to discuss model validation in their field. There were 23 presentations divided into four topical sessions and summarizing discussion time at the end of each session. The meeting was organized by the PWI TF special experts working groups "Material Migration" and "ITER Material Mix", participants representing the associations of eight member countries, EFDA and IAEA. The local organizer was Association Euratom-Tekes (Aalto University and VTT Technical Research Centre of Finland).

Probably the most acute positive news reported in the meeting were the ones concerning the JET ILW, to be commissioned next summer, which will consist of the ITER materials beryllium and tungsten. Two independent simulations on tungsten erosion and migration predict that the core plasma is well screened from tungsten except at very low fuelling rates.

The meeting concluded that simulation tools are developing at giant leaps towards a comprehensive modelling of the PWI issues: New global material mixing models not only calculate the migration routes of materials and treat the forming layers as chemical phases instead of elements, but in doing that they introduce the results of 20 years of PWI modeling into global SOL modeling codes and even predict how the newly formed materials can fulfil the requirements. EIRENE-TIM represents another attempt for comprehensive modelling by offering the capability of simultaneous modelling of neutrals, ions and photons. Another step towards realistic simulation of edge phenomena is represented by codes that are now capable of extending the simulation domain all the way to the wall (SOLPS, DIVIMP, ASCOT) and using detailed 3D CAD models to represent the structures (ASCOT). Also ripple and other non-axisymmetric magnetic features can now be included (ASCOT).

Also topics requesting urgent attention were identified: boundary conditions at the wall were seen as insufficient because re-erosion and/or sticking are currently either neglected or treated heuristically. Consequently, re-erosion / sticking models are undergoing fast development in terms of including experimental and molecular dynamics simulation data, taking into account also erosion by dissociation products of molecules. Another process that was found to be of key importance for impurity transport but which is poorly understood is the scrape-off layer (SOL) flows. Unfortunately, most fluid codes producing the background plasma conditions for other codes cannot presently reproduce the measured SOL flows. The SOLEDGE code has improved the understanding of plasma flows in limiter tokamaks, bringing the stagnation point to the proper location in the high field side, but its application to divertor tokamaks has proven more complicated.

Before the workshop dinner on Tuesday, a former fusion physicist, Dr. Ville Hynönen, presently working as reactor physicist in the Finnish power company TVO, gave a presentation on the status of large TVO projects, construction and planning of two new large nuclear units in Olkiluoto.

The Tervaniemi meeting stems from a biannual informal German-Finnish workshop held in Tervaniemi since 2005. Traditional Finnish winter amusements like cross-country skiing, sauna and swimming in the frozen lake Alasjärvi were enjoyed also by this year's participants.

Individual session summaries

Session 1: Marker experiments (^{13}C injection, smart tiles)

ERO modelling of local gas injection experiments in TEXTOR, AUG, and JET has been discussed in detail. Improvement of the modelling were done with the aid of MD calculated sticking factors for hydrocarbons, the inclusion of neutral hydrogen from CH_4 break-up [presentations of Borodin (on behalf of Kirschner), Airila and van Hoey] and the connection with the GAP code (Matveev) to model and simulate gap areas. However, still enhanced re-erosion of a-CH layers is needed in order to reproduce the modelling results of local puffing experiments. The enhanced re-erosion is used for layers only and can be attributed to an ion sputtering process. No such enhanced sputtering is necessary for remote areas. Benchmark experiments in AUG L-mode plasmas with SOLPS-ERO revealed the important role of ExB forces as well as the impact of surface roughness on the deposition pattern (Aho-Mantila). New experiments in particular in AUG are proposed in order to have best as possible access to global material migration from the main chamber (Hakola). The AUG experiment shall be seen in connection with JET global injection experiments and shall answer the role of flows and the assumption of toroidal symmetry.

Session 2: Far scrape-off layer transport

The session dealt with the topic of modelling far Scrape-Off Layer fluxes, which are important both as a source of impurities (from the wall) and for migration of material around the machine, e.g. via SOL flows. The talks could be divided into three areas. The first group of talks dealt with recent extensions of numerical codes to the wall, including ASCOT (Miettunen), SOLPS/EIRENE (Wiesen) and DIVIMP (Lisgo/Krieger). The second focussed on turbulent transport and their modelling, specifically the topic of SOL flows (Tamain) and effect of transients of fluid codes (Naulin). The deputy leader of the EU TTG also gave an update on related edge turbulence activities in the EU (Naulin). Finally, the chairman (Fundamenski) presented recent development on measuring SOL widths in JET in D, H and He plasmas, their interpretation suggesting a combination of electron heat conduction and drift ordered radial velocity, and examined a new dimensionless approach at studying SOL fluxes.

Session 3: Surface dynamics

The session was focussed on the development of ITER-relevant material mixing models for two codes: ERO and WALLDYN. Borodin and Airila reported updates in the ERO surface models related to beryllium carbide formation and underlying data sets. Data input from molecular dynamics calculations to ERO is strengthening. Beryllium simulations of ERO have been extensively benchmarked on linear

machines and ITER simulations are being extended to include main wall erosion. Schmid and Reinelt presented the implementation and benchmarking on the WALLDYN code designed for efficient global simulations of surface dynamics. WALLDYN can accommodate various plasma transport models and its flexibility concerning coupling to other codes is being improved. The kinetic/thermodynamic wall processes have been already benchmarked, first parameter scans of plasma transport are ongoing and will be carried out using data from JET in particular. Finally Costin gave a more experimental presentation 2D I_{sat} and V_f measurements at Pilot-PSI.

Session 4: Kinetic modelling

The session consisted of contributions on kinetic transport modelling codes, e.g. code-code benchmarking between kinetic codes and fluid codes. The newly developed EIRENE-TIM (Trace Ion Module) is capable of kinetic simulation of ions, neutrals and photons simultaneously and is presently in the verification phase. It has already been applied to carbon and tungsten transport in JET (Seebacher) and tungsten transport in AUG (Wischmeier on behalf of Reimolt). Seebacher presented also the talk of Groth on EDGE2D/EIRENE, DIVIMP, and EIRENE-TIM code-code benchmarking for carbon. DIVIMP simulations of tungsten transport in JET indicate that tungsten transport to core plasma is strongly suppressed at moderate and high densities, which helps keeping the core tungsten concentrations low (Järvinen). Makkonen presented a detailed comparison between DIVIMP, ASCOT and the Reiser model applied to Coloumb collision test and a carbon transport test case. It was shown that the temperature gradient force explains the major differences between various models.