4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

The Integrated Modelling and Analysis Suite: Status of development and application to ITER scenarios

S.D. Pinches[1], L. Abadie[1], H. Ancher[2], X. Bonnin[1], F. Carpanese[3], F.J. Casson[4], G. Corrigan[4], S. Dixon[4], L. Fleury[2], D. Harting[4], T.W. Hayward-Schneider[5], O. Hoenen1,[5], J. Hollocombe[4], M. Hosokawa[1], F. Imbeaux[2], A.A. Ivanov[6], T. Jonsson[7], L. Jung[8], R.R. Khayrutdinov[9], S.H. Kim[1], P.J. Knight[4], F. Köchl[4], S.V. Konovalov[9], Ph. Lauber[5], V.E. Lukash[9], S.Yu. Medvedev[6,9], A. Merle[3], V. Mitterauer[1,5], M. Owsiak[10], B. Palak[10], A. Popa[5], A.R. Polevoi[1], M. Romanelli[4], O. Sauter[3], M. Schneider[1], G. Tardini[5], L. Van Dellen[11]

[1] ITER Organization, [2] CEA, [3] EPFL, [4] CCFE, [5] IPP Garching, [6] Keldysh Institute of Applied Mathematics, [7] KTH, [8] NFRI, [9] Kurchatov Institute, [10] PSNC, [11] FIRCROFT

e-mail (speaker): Simon.Pinches@iter.org

The Integrated Modelling & Analysis Suite (IMAS) is the software infrastructure that is being developed building upon the modelling expertise from across the research facilities within the ITER Members to support the execution of the ITER Research Plan [1]. It is built around a standardised representation of data described by a Data Dictionary that is both machine independent and extensible. Machine independence is important since it allows tools and workflows developed in IMAS to be tested and refined on existing devices, whilst extensibility allows the Data Dictionary to grow and evolve over time as more Use Cases are addressed. The use of standardised Interface Data Structures (IDSs) fosters the creation of modular physics components and (sub-)workflows that can be flexibly re-used to address different needs.

One of the focal points driving development within IMAS is the creation of a high-fidelity plasma simulator that can be used to predict ITER plasma performance. The DINA code [2,3] has been extensively used to validate the capability of the ITER poloidal field system to support the plasma scenarios foreseen in the ITER Research Plan. It includes a free-boundary equilibrium evolution solver implementing feedback control of the plasma current, position and shape, taking into account eddy currents in the vacuum vessel, as well as numerous engineering limits imposed on the coils, their power supplies, and plasma-wall gaps. The JINTRAC code [4] refines the physics description in the plasma core and also couples its behaviour with that in the plasma edge. It can describe plasma heating, fuelling and transient behaviour.

An additional high-fidelity ingredient that has been recently developed by a combination of ITER Staff, ITER internships, ITER Scientist Fellows and voluntary contributions, is a comprehensive heating and current drive (HCD) workflow that is capable of describing all of the ITER heating systems as well as synergistic effects between them. This workflow exemplifies the IMAS integrated modelling paradigm and has driven further refinements in the IMAS infrastructure. It builds upon the extensive work carried out within the EUROfusion Work Package for Code Development (WPCD) and is implemented in Python to facilitate distributed development and portability.

The IDS-based database of ITER scenario simulations is continuously expanding and is used to support ITER design activities including assessments of the ITER heating systems and diagnostics. Recent additions include the set of SOLPS4.3 simulations of ITER edge conditions and JINTRAC simulations of ITER L [5] and H-mode [6] conditions.

In preparation for the Live Display of information during ITER operations, work has started on the creation of displays using the scenario information contained within the ITER scenario database together with synthetic diagnostics. Figure 1 shows a still frame of an evolving Live Display derived from data calculated with the METIS [7] and SOLPS-ITER [8] physics codes.

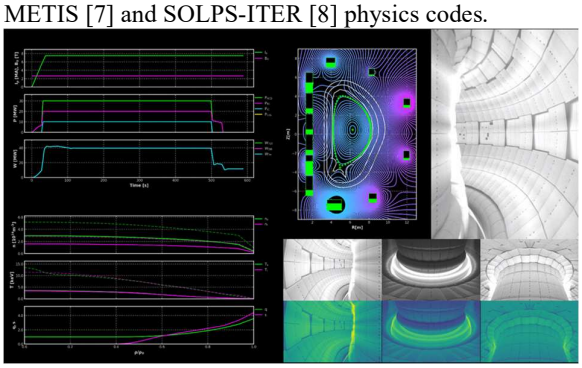

Figure 1: Example control-room Live Display calculated using ITER scenario database and showing plasma equilibrium, waveforms and profiles (based on shot=110005; run=1), together with synthetic views from the Wide Angle Viewing System (WAVS).

The views and opinions expressed herein do not necessarily reflect those of the ITER Organization.

References

[1] ITER Research Plan within the Staged Approach: https://www.iter.org/technical-reports
[2] R. R. Khayrutdinov, V. E. Lukash, J. Comput. Phys. 109 (1993) 193
[3] V.E. Lukash et al., Plasma Devices and Operations 15 (2007) 283
[4] M. Romanelli et al., Plasma Fusion Res. 9 (2014) 3403023
[5] E. Militello Asp et al., TH/P2-23, IAEA FEC 2016, Kyoto, Japan
[6] L.Garzotti et al., Nucl. Fusion 59 (2019)
[7] J.F. Artaud et al., Nucl. Fusion 58 (2018) 105001
[8] S. Wiesen, et al., J. Nucl. Mater. 463 (2015) 48