§6. Systematic Validation Study based on Experiment Database through Extension of Integrated Transport Analysis Suites for LHD and Toroidal Plasmas

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The integrated transport analysis suite, TASK3D-a (Analysis), has been developed to be capable for routine whole-discharge analyses of plasmas confined in threedimensional (3D) magnetic configuration such as the LHD.

The routine dynamic energy balance analysis [1] for NBI-heated plasmas was made possible in the first version released in September 2012. Recently, the suite has been further extended through implementing additional modules for neoclassical transport and ECH deposition (LHDGauss [4]) for 3D configurations. The module has also been added for creating the systematic data for the International Stellarator-Heliotron Confinement and Profile Database (ISH-DB). Data uncertainty quantification (UQ) tool [2] and improvement of NBI modules for multiple-ion species plasmas [3] are also highlights of recent development. The entire module structure in TASK3D-a02 (second version) is schematically shown in Fig. 1.

Neoclassical energy diffusion flux can also be routinely calculated by the implemented GSRAKE code [4], and thus, systematic comparison with experimental energy balance has been available. An example is shown in Fig. 1. Here, time-dependent comparison for ion energy transport is shown for a certain radius of a high-ion-temperature discharge. This comparison is available not only at a particular radius, but from the center to the edge, by simply executing TASK3D-a02 with only specifying the shot number. These kinds of data have been accumulated for elucidating turbulent transport contribution in a wide parameter space of LHD plasmas.

Utilizing the TASK3D-a development, the ISH-DB takes also an advantage from the LHD unified data that can be used verification and validation (V&V) studies of large simulation codes for Stellarator-Heliotrons. The TASK3D-a has already provided profiles and equilibrium data to several large-scale simulation codes such as gyrokinetic instability, energetic particles/Alfvén eigenmodes, and neoclassical plasma flows. The TASK3D-a data interface to ISH-DB has much simplified and enhanced V&V studies of large simulations.

Much further extensions should be pursued towards full-integration by incorporating modules for other physics process such as re-distribution of energetic particles, particle transport issues. This work has been supported by NIFS Collaborative Research Programs NIFS11UNTT006. The one of authors (MY) also acknowledges the grant-in-aid from the Future Energy Research Association.

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Fig.1: Calculation flow of TASK3D-a02 ("a01" released in Sep. 2012, and "a02" for recent extensions. Bold uppercase letters indicate the module (numerical code), and italic ones the I/O data from/to the LHD Analysed Data Server. All the calculations are conducted at all the timings of Te measurement



Fig.2: Time-dependent comparison between experimental and neoclassical ion energy flux at a certain radius of a high-ion-temperature discharge. This data can be easily obtained by the execution of TASK3D-a02.