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Development of Integrated Transport Code, TASK3D, and its Applications to LHD Experiment
ヘリカルプラズマ統合輸送コードTASK3Dの開発と実験適用

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The integrated transport analysis code for helical plasmas, TASK3D, has been developed both by modifying TASK [1] modules to be applicable to three-dimensional magnetic configurations, and by adding new modules for stellarator-heliotron specific physics. In this talk, these module developments so far are collectively introduced, and recent progress on the applications to LHD experiment are described.

1. Introduction

The Large Helical Device (LHD) experiments have steadily expand the parameter regime of helical plasmas such as electron and ion temperatures, beta value, electron density, pulse length and total input energy to plasma in a long-pulse operation as summarized in Ref. [2]. The wide-range applicability of the integrated code is mandatory, and, in the mean time, experimental verification of each module and its integration should be performed by utilizing the experiment database.

2. Outlook and Present Status of TASK3D Development

Figure 1 shows the overview of module components of TASK and TASK3D to show how TASK3D has been extended and will try to deal with stellarator-heliotron specific and three-dimensional equilibrium. The integration of these modules is in progress.

The radial transport aspect of TASK3D employs the diffusive transport equation [module, **TR**] with the local diffusivity (particle and heat) and the particle and heat source/sink term. Taking three-dimensional configuration's impact into account such quantities have been main focus of module modification/supplement in TASK3D development. In the following, a few examples are described in brief.

[Neoclassical diffusion and radial electric field, **DGN/LHD, ER**] The presence of the ripple transport (so called 1/ν diffusion) is specific feature in non-symmetric magnetic configurations. The ambipolarity of neoclassical (NC) particle fluxes has been demonstrated to well describe the bifurcation nature of the radial electric field (Er) in LHD and other helical plasmas [3,4]. Thus, it is of a great importance to accurately calculate the neoclassical fluxes, and then Er. For this purpose, the diffusion coefficient database, DGN/LHD [5], has been prepared for a wide-range of equilibria by utilizing advantages of NC transport codes, DCOM [6] and GSRAKE [7]. This highly-accurate NC module has made it possible to compare with the power-balance analysis to elucidate the turbulent transport contribution [8].

[Time evolution of iota (current) profile, **EI**] The three-dimensional magnetic configuration's impact on the current evolution through the susceptance matrix components is formulated [9]. The evolution of the rotational transform profile evaluated through this current evolution equation is compared to show the same trend (even quantitatively) with Motional Stark Effect (MSE) measurement.

[NBI deposition analysis, **FIT3D, MORH**] As for the NBI deposition analyses, FIT3D code [10] has been routinely employed in LHD experimental analysis. To examine the impact of re-entering particles especially for high-beta and/or low magnetic field conditions, new module (MORH [11]) has been developed based on the HINT equilibria. Experimental verification has been pursued.

3. Recent Progress on Applications to LHD Experiments

The interpretive power-balance analyses package, **TR-snap** [12], has been developed based on combinations, so far, of TR, VMEC and FIT3D and MORH modules. It has been applied to LHD plasmas to evaluate heat diffusivity and investigated the impact of re-entering NBI particles on it [12].

The predictive simulations on achievable temperature (profiles as well) have been also recently performed based on TR, VMEC, FIT3D, ER and DGN/LHD modules (for neoclassical diffusion contribution) along with assumed anomalous contribution to heat diffusivity [13]. The dedicated experiment measuring profiles required for relevant interpretive simulations was recently conducted to validate/provide modification such simulation results. The comparison between predictive and interpretive simulations will be made, and presented in detail in [13].

4. Concluding Remarks

The development of integrated transport code, TASK3D, and applications of combined modules to LHD experiments have been steadily progressed. Validation studies will be extensively made to increase the predictability for future experiments and even reactor plasma simulations.

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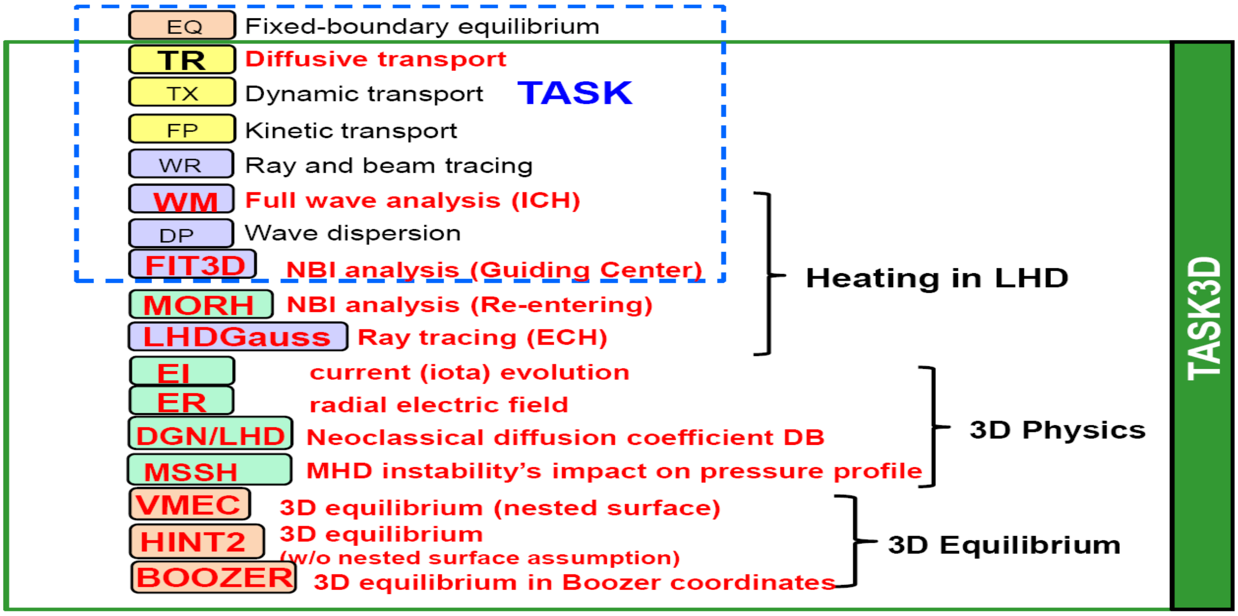

Fig.1. An overview of module components of TASK and TASK3D. Modules, utilized/will be utilized for TASK3D, are denoted in bold characters. They are categorized to heating modules for LHD (NBI, ICH and ECH), stellarator-heliotron specific physics and three-dimensional equilibrium. They have been developed piece-by-piece basis.