Data Assimilation for Particle and Heat Transport of LHD Plasma

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Integrated simulation for fusion plasmas has various uncertainties in each employed simulation model, specifically the turbulent transport model. Because of this, the simulation results also have uncertainties. To solve this problem and predict the behavior of fusion plasmas with high accuracy, we are developing a data assimilation system, ASTI[1,2], based on the integrated transport simulation code, TASK3D[3], for Large Helical Device (LHD) plasmas. As data assimilation methods, we use the ensemble Kalman filter (EnKF) [4] to predict the behavior of fusion plasmas with high accuracy and the ensemble Kalman smoother (EnKS) [4] to estimate the model parameters which can reproduce experimental data.

We apply ASTI to an experimental time series data set of LHD (shot: 114053). The state vector comprises the electron and ion temperature, density, parameters of turbulent models (particle and heat transport coefficients and convective velocity), and model parameters of neutral beam injection (NBI) heating. The temperature and density time series data are assimilated into the integrated transport simulation. This assimilation have been performed with 500 ensemble members for the cycle of assimilation, $\tau_{\mathrm{DA}} = 80$ msec. ASTI has been reproduced the radial profiles of the density and temperatures of ion and electron and the temporal variations by optimizing simultaneously the employed turbulent transport models and NBI heating model parameters. The model parameters which can reproduce the spacial and temporal variation of observation data have also been obtained by the EnKS. These results indicate the effectiveness and validity of the data assimilation approach for accurate prediction of fusion plasmas and estimation of model parameters.

[1] Y. Morishita *et al*., Nuclear Fusion **60**, 056001 (2020).

[2] Y. Morishita *et al*., Plasma Fusion Res. **16**, 2403016 (2021).

[3] S. Murakami *et al*., Plasma Phys. Control. Fusion **57**, 119601 (2015).

[4] G. Evensen, Ocean Dynamics **53**, 343-367 (2003).