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Implementation of ECH power absorption model to DYON and its validation in KSTAR

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Importance of plasma startup with electron cyclotron heating (ECH) assistance has been emphasized to overcome the anticipated difficulty of plasma startup at future superconducting tokamak, especially ITER. In ITER, available toroidal electric field at startup phase is limited as 0.3 V/m due to the operation limit of superconducting solenoid coils [1]. Stable and robust plasma startup with ECH-assistance have to be studied for reliable operation of ITER [2].

As a 0-dimensional plasma burn-through simulator, DYON has shown impressive results of the startup modeling. The code have advanced impurity model of thorough impurity balance equation and a plasma-wall interaction [3]. The simulation results not only the plasma current, electron density, and temperature but also the radiative loss power were quantitatively compared to the JET experimental data [4, 5]. After the validation, DYON was also used to anticipate the startup condition of ITER [6]. It was anticipated that the operation window, especially the prefill pressure, is quite narrower than JET ITER-like wall, but it could be expanded by ECH power of few MW. This calculation, however, based on the assumption that the absorption efficiency of injected EC power is 100 %. It could be suitable for fundamental harmonic ECH heating, but not for 2nd harmonic condition.

A self-consistent ECH power absorption model was used 0D startup simulator, TECHP0D [7, 8], which was developed to study first plasma startup in KSTAR [9]. The model calculates the optical thickness of injected ECH wave as a function of plasma density, temperature, and ECH specifications such as injection angle, frequency, etc [10].

To improve the DYON, we applied the ECH power absorption model and verified it through the KSTAR startup experiments. ECH power absorption coefficient is self-consistently calculated every time step in DYON. To validate the improved DYON code, we applied the simulation conditions to represent KSTAR, especially first wall made by carbon. Other parameters such as the deuterium recycling coefficient, ECH condition, and the fueling efficiency are newly found to fit the KSTAR situation with benchmarking the ohmic startup scenario. The preliminary results of reproducing KSTAR ohmic scenario using DYON is presented in figure 1. As a next step, the ECH-assisted startup experiment in KSTAR is benchmarked to confirm the reliability of the integration of ECH model and burn-through simulation. Finally, the improved DYON code is applied to ITER startup simulation with 2nd harmonic EC-assistance condition.

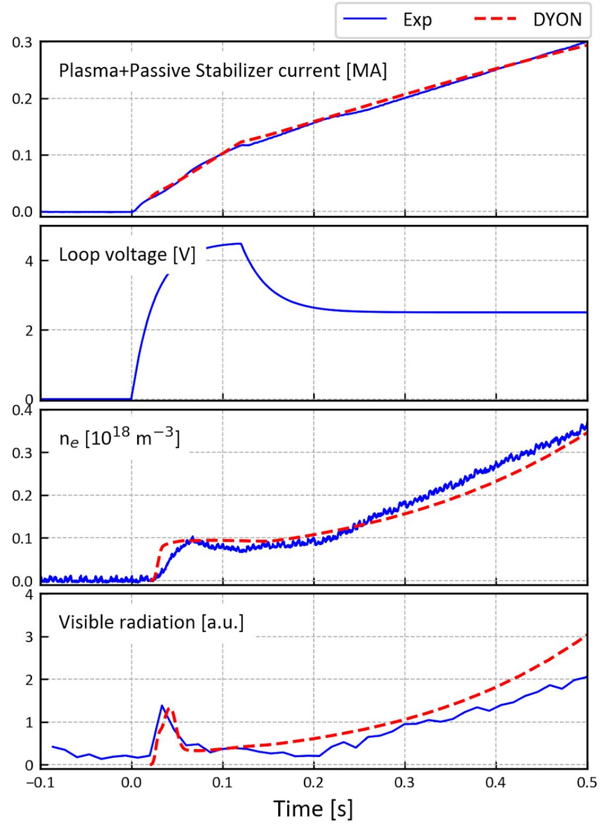

Figure 1. Preliminary benchmarking results of typical pure ohmic startup experiment in KSTAR (#12301) using DYON.

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