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Integrated modeling of runaway electrons in JA-DEMO disruptions

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In reactor-grade Mega-ampere tokamak devices, the mitigation of the disruption loads is mandatory to ensure the routine operation. In particular, the heat load by runaway electrons can be localized, resulting in the unacceptable damage on the in-vessel components. Therefore, it is necessary to evaluate the runaway electron load and understand the runaway mechanisms.

Recently, the disruption mitigation scheme by shattered pellet injection has also been studied towards ITER, and the assessment of such mitigation to DEMO is a key topic for the fusion development research. For an application to such assessment, we have developed the disruption integrated code INDEX [1] based on the 1.5D tokamak models, where the equilibrium and transport equations are self-consistently coupled to simulate the vertical displacement events, thermal quench, current quench, and the runaway generation.

The runaway generation model, including the Dreicer mechanism, the tritium beta-decay and the Compton scattering of the gamma-ray, to evaluate the runaway current generation, have newly been implemented in the INDEX code, which enables us to evaluate the time-development of the runaway current behavior during the VDEs. Figure 1. shows the example of the time development of the plasma current, the runaway and plasma current profiles, and the temperature profiles in ITER-like circular tokamak. This calculation is the benchmark with the previous research about runaway electron generation by a European code GO [2]. Here, the impurity (Ne) density is set as $n_{Ne} = 1 \times 10^{20}$[m^{-3}], assuming the massive material injection. The implemented model has successfully been benchmarked. Also, Fig 2. shows the example of runaway current generation in JA-DEMO, assuming Ne-injection. We does not include the Halo current effect and scraping off the runaway current, above. We shows the results of the Ne-injection scenario, but it is considered that D_2 injection might reduce the runaway electron load to the wall [3].

We will evaluate the current quench time and the runaway beam deposition in JA-DEMO. This talk presents a first assessment of the RE beam dynamics on the JA-DEMO tokamak and compares the expected loads with ITER disruption mitigation scenarios.

References

[1] A. Matsuyama et al., Proceedings of the 28th IAEA Fusion Energy Conference (online, May 10-15, 2021), TH/P3-12 (2021).
[2] O. Vallhagen et al., Journal of Plasma Physics, 86 (2020) 475860401.
[3] C. Paz-Soldan et al., Nucl. Fusion 61 (2021) 116058.

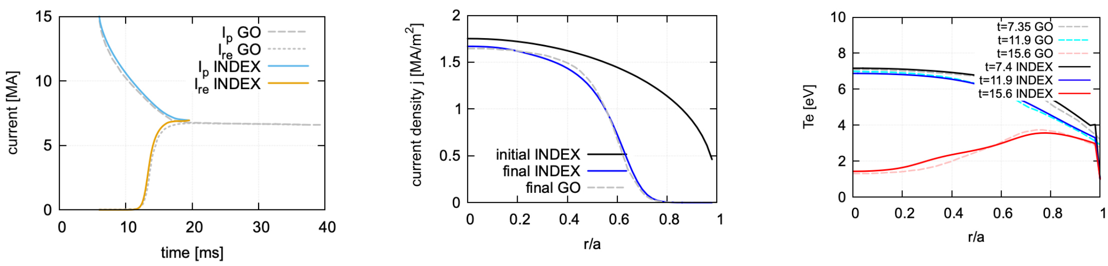

Figure 2. The time development of the plasma current, the runaway current profiles, and the temperature profiles in ITER-like circular tokamak.

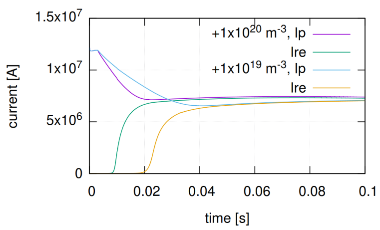

Figure 1. The example of the time development of the plasma and runaway current in JA-DEMO.