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Disruption prediction based on disruption budget consumption on J-TEXT

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The successful operation of tokamak devices, such as ITER, depends on effectively managing disruptive events. These occurrences can abruptly terminate discharges and trigger thermal and current quenches, posing severe threats to device structural integrity. Thus, precise disruption budgeting is essential to achieve operational objectives.

Disruption damage is quantified through a disruption budget consumption (DBC) approach, evaluating the electromagnetic and thermal load released during disruptions under various plasma conditions. DBC serves as a measure of the potential "cost" incurred by disruptions, which cumulatively affect device lifetime. Accurate DBC formulation is crucial for achieving low disruption rates and high mitigation success rates.

Prediction and mitigation strategies are important for reaching operational goals. Achieving target disruption rates necessitates the development of avoidance and prediction strategies, while effective mitigation depends on reliable disruption prediction techniques and efficient mitigation measures. Accurate prediction relies on robust models that leverage DBC-informed insights and experimental data.

Disruption damage comes from thermal and electromagnetic load. Thermal load mainly affects first wall integrity, with pre-thermal quench parameters identified as critical. Electromagnetic load arises from current quenches, particularly affecting vacuum vessel and inducing eddy currents in the first wall.

For DBC quantification, key parameters include plasma current, toroidal field, radiation power, and current quench rate. Training datasets should contain a large range of operational scenarios while ensuring device safety lifetime. Machine learning models trained on DBC-informed datasets enhance disruption predictive capabilities with limited DBC on device. Future device operation benefits from DBC-guided discharge management, assigning a "cost" to each discharge to optimize data collection while protecting the device.

Speaker's Affiliation

Huazhong University of Science and Technology, Wuhan

Member State or IGO

China, People's Republic of

Primary author: ZHONG, Yu (Huazhong University of Science and Technology)

Co-authors: Mr SHEN, Chen Shuo (Huazhong University of Science and Technology); Mr XUE, Feng Ming (Huazhong University of Science and Technology); Mr LUO, Run Yu (Huazhong University of Science and Technology); Mr ZHENG, Wei (Huazhong University of Science and Technology); Mr AI, Xin Kun (Huazhong University of Science and Technology); Mr DING, Yong Hua (Huazhong University of Science and Technology); Mr CHEN, ZhongYong (Huazhong University of Science and Technology)

Presenter: ZHONG, Yu (Huazhong University of Science and Technology)

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