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High heat flux in the far SOL during steady-state discharges in EAST

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In recent campaigns, one of the aims of EAST is to achieve long pulse plasma discharges with an auxiliary power of 10 MW. However, several main limiters have been severely damaged in recent campaigns, as shown in Fig. 1. Although the main limiter has been upgraded to a tungsten/copper flate-type limiter with the heat load capacity of 20 MW/m^2, many unacceptable damages still have been observed after summer campaign in 2022 [1, 2]. Therefore, we are urgent to know whether there is a heat flux that far exceeds the probe data, because it is very important to the optimization of the main limiter in the next time.

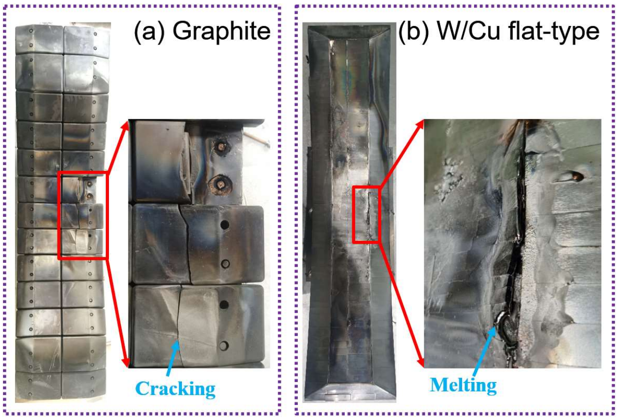

Fig. 1 The damages on the graphite (a) and W/Cu flat-type main limiters. The graphite and W/Cu flat-type main limiters were used in 2021 and 2022 campaign, respectively.

In this work, a method for inverse calculation of parallel heat flux based on the measured surface temperature has been successfully developed. In the method, a key parameter inputted into ANSYS code, the heat power distribution, is calculated by PFCFlux code, while different decay widths are used to describe the parallel heat flux profile. Utilizing the method, the temperature distribution on the main limiter and its time evolution during 1056-s discharge have been well reproduced, as present in Fig. 2.

The results suggest that the parallel heat flux inversed from the method can be four times larger than the probe data during high-power discharges, while it is close to the probe data during low-power discharges. The parallel heat flux deposited on the main limiter can reach up to 28.7 MW/m^2. The corresponding heat power deposition is about 9.8 MW/m^2, which exceeds the tolerance limitations of the graphite limiters. Besides, a series of dedicated experiments suggest that a notable increase of 27.52 MW/m^2 in the parallel heat flux is found as the power of ICRF increases by 1 MW, as shown in Fig. 3. The high heat flux in the far SOL is a big challenge to the plasma operation and engineering design.

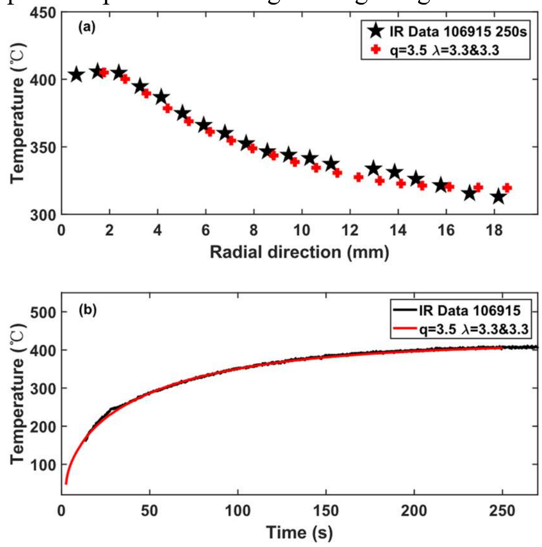

Fig. 2 The temperature distribution along the surface of graphite tile at 250.0s (a) and the time evolution of the discrete temperature peak (b) during discharge #106914.

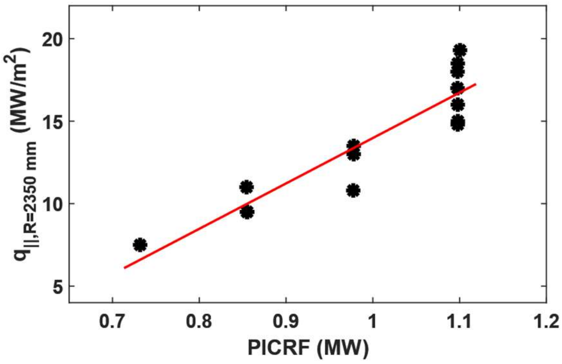

Fig. 3 The relationship between the parallel heat flux at the radial position of 2350 mm and ICRF power.

Some evidences indicate the main reason for the high heat flux is fast ions generated by ICRF waves [3], which is hard to be measured by probes. Although, the parallel heat flux can be mitigated by increasing the core plasma density and the ratio of H/(H+D), the mitigation is very limited. It is still necessary to optimize the design of the main limiter according to the parallel heat flux profile obtained from this work.

References

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