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Experimental research and analysis on energetic ion confinement quality in plasma core region during MHD instabilities in the HL-2A tokamak

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Researches on energetic ion confinement behaviors which are of great importance for magnetic confinement fusion plasmas have been intensively performed in the HL-2A tokamak [1], as well as other magnetic confinement devices [2]. The energetic ion confinement quality estimation in the core region of fusion plasmas can be expected by means of neutron measurements [3]. Since magnetohydrodynamic (MHD) instabilities such as toroidal Alfvén eigenmodes (TAEs) and resistive interchange modes (RICs) lead to energetic ion losses in the order of sub-millisecond [4], a high temporal-resolution neutron flux measurement (HTRNFM) system has been developed and put into application at the end of the 2021 HL-2A experiment campaign [5].

The continuous reduction of neutron flux, which reflects the continuous losses of energetic ions induced by MHD instabilities [6], is observed with the HTRNFM system reducing by ~60% during the coexistence period of long-lived saturated internal mode (LLM), tearing mode (TM), and sawteeth, and the abrupt reduction of neutron flux, which reflects the instantaneous losses of energetic ions, is also observed with the HTRNFM system reducing by ~85% when a minor disruption occurs (see figure 1).

In order to analyze the experiment data, theoretical calculations for the evolution of neutron yields with FBURN code [7] have been carried out (see figure 2). The abrupt reduction of neutron flux during minor disruption is reproduced in the calculation, which proves that minor disruptions are destructive to the energetic ion confinement quality. However, the continuous losses of energetic ions induced by LLM, TM and sawteeth are not successfully reproduced in the calculation. The deviation indicates that LLM, TM and sawteeth degrade the energetic ion confinement quality to some extent, which is verified by the ion temperature profile data obtained from CXRS.

References

[1] Pei-Wan Shi, et al., Chin. Phys. Lett. 38 (2021) 035202.
[2] N.N. Gorelenkov, et al., Nucl. Fusion 54 (2014) 125001.
[3] B. Wolle, Physics Reports 312 (1999) 1-86.
[4] K. Ogawa, et al., Nucl. Fusion 50 (2010) 084005.
[5] J. Zhang, et al., J. Instrum. 2022 (accepted).
[6] Y. P. Zhang, et al., Nucl. Fusion 55 (2015) 113024.
[7] K. Ogawa, et al., Plasma Phys. Control. Fusion 60 (2018) 095010.

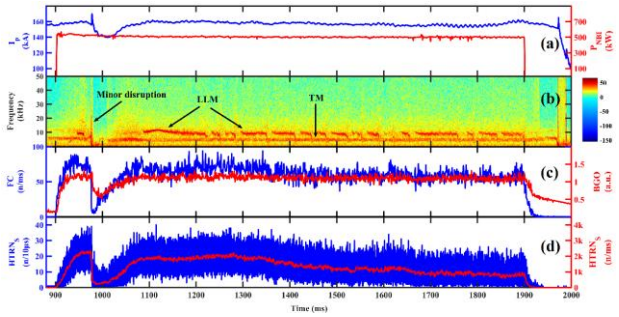

Figure 1. Time traces of relative parameters.

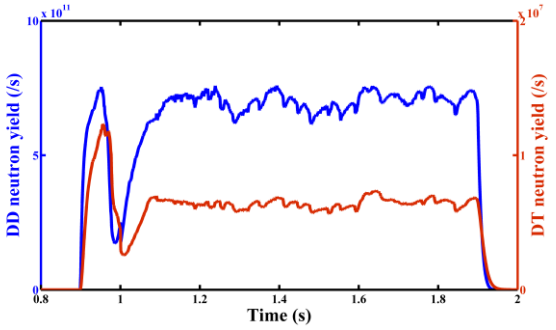

Figure 2. Time traces of neutron yield calculated with FBURN code.