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Suppression of runaway electron generation by LBO during disruptions in the HL-2A Tokamak

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Runaway electrons (REs) are a crucial issue for future large tokamaks, especially during disruptions, due to the local impact of RE beam and large thermal loads they can place on the plasma facing components [1]. Therefore, a very active field of research has been opened up in the past decades on RE dynamics during disruptions [2]. Utilizing the newly developed key systems in the HL-2A tokamak for the study of RE dynamics during disruptions, such as: hard X-ray (HXR) camera, laser blow-off (LBO) system, and massive gas injection (MGI) system, the effects of laser blow-off (LBO) on RE dynamics during disruptions have been systematically investigated. RE generation during disruptions has been successfully suppressed by the LBO-seeded impurity. With the aid of a hard X-ray (HXR) camera, the physical mechanism of the RE dynamics during disruptions has been observed and these allow a detailed analysis of the suppression of the REs.

The quantity of impurities injected by LBO can be flexibly adjusted by varying the diameter of the laser beam. In this experiment, tungsten (W) was injected into the plasma before disruption. The target thickness and the LBO laser spot diameter are 5 μm and 4 mm, respectively. Figure 1 is the time evolution of the main parameters of a typical suppression of disruption-generated runaway electorns by LBO-seeded impurity. Before disruption, metal impurities were injected into the plasma by LBO at 980ms. With the impurity injection, strong magnetic fluctuation was excited about 5 ms after LBO, as shown in Figure 1(d). The singular value decomposition analysis for the Mirnov signals indicates the poloidal and toroidal mode numers are m/n=2/1. At 990ms, plasma disruption was triggered by MGI. It can be observed that no runaway current plateau was formed during disruption. The images of RE beams were obtained by an infrared camera. It can be clearly seen that there is no RE beam during disruption with LBO. The measurement results from the HXR camera [3] show that almost all energetic electrons are lost under strong magnetic fluctuation before disruption. That is, the "seed" electrons that form the RE beam are "killed" [4], which prevents or suppresses the generation of REs during disruption. Moreover, the dependence of the RE generation avoidance on the LBO parameters has been found, indicating the impurity quantity and injection time is likely the key parameter for RE avoidance during disruptions.

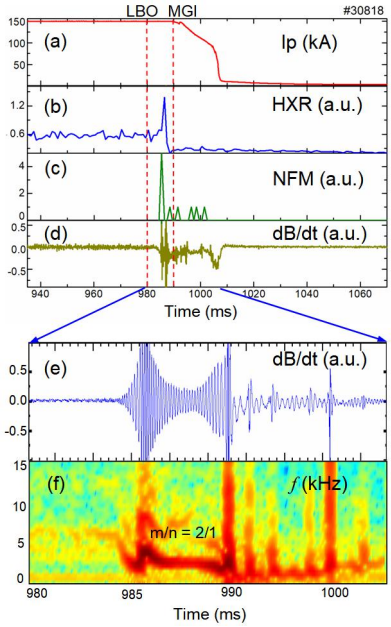

Figure 1. A typical suppression of disruption-generated runaway current by LBO-seeded impurity in HL-2A. (a) Plasma current Ip. (b) Hard X-ray emission intensity HXR. (c) Neutron flux monitor NFM. (d) Magnetic probe signal measured by the Mirnov coil. (e) and (f) Magnetic probe signal and its frequency spectrogram.

References

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