MFP8

1st Asia-Pacific Conference on Plasma Physics, 18-23, 09.2017, Chengdu, China

Observation of relativistic runaway electrons with a wide-angle infrared periscope system in HL-2A

J.M. Gao, Y.B. Dong, Y. Liu, Y.P. Zhang, C.Y. Chen, W. Li, X.Q. Ji, Y. Zhou, and Q.W. Yang

Southwestern Institute of Physics, China

Runaway electrons with energies in the order of several tens of megaelectron volts (MeV) have been observed during tokamak disruption and low density discharges [1,2]. These relativistic runaway electrons can cause substantial damage to the plasma facing wall components of fusion devices. It is therefore necessary to understand the dynamics of these high-energy runaway electrons in experiments. Runaway electron is typically investigated by measuring the thick-target bremsstrahlung emission or neutron emission produced by the lost runaway electrons hitting the limiter or vessel structures [3,4]. These methods, however, can not provide the information of runaway electrons directly, especially the relativistic electrons in the core of plasma. Synchrotron radiation emitted by the relativistic runaway electrons is in the (near) infrared wavelength range, which can easily be detected by thermographic cameras. So the synchrotron radiation may be a powerful tool for direct observation and investigation of the relativistic runaway electrons.

A new wide-angle infrared periscope system has been developed for the HL-2A tokamak to measure the synchrotron radiation, which is originated from the relativistic runaway electrons during plasma disruption and low density discharges. This diagnostic is installed on the outer mid-plane of the tokamak and the wide-angle design allows to have a full poloidal view of the HL-2A vessel, as shown in figure 1. The line of sight of the infrared camera is tangential to the plasma in the direction of electron approach. Measurements of relativistic runaway electrons using this system have been performed, and the dynamics of the relativistic runaway electrons are investigated. Based on the measurements, the pitch angle $\theta = 0.13rad$ is estimated, and the runaway energy $E_{re} = 20 \pm 3MeV$ is deduced typically. However, the runaway electrons with energy of $E_{re} > 30MeV$ are observed during lower hybrid current drive (LHCD) in the low density discharges.

In the dedicated experiment of runaway current mitigation during plasma disruption with supersonic molecular beam injection, this diagnostic technique has been used to follow the time evolutions of runaway beam, providing the direct information about the mitigation process. The helium gas injection leads to a pitch angle scattering process, characterized by the enhanced synchrotron radiation losses of relativistic runaway electrons. The synchrotron spot is also charged strongly in this process. Subsequently, the energy of relativistic runaway electrons is reduced, and then the runaway current decreases gradually. It suggests that the SMBI technique is a useful tool for the runaway mitigation.

References

[1] R. Jaspers, N.J. Lopes Cardozo, A. J. H. Donne, et al. Rev. Sci. Instrum. **72** (2001) 466.
[2] E. M. Hollmann, P.B. Parks, N. Commaux, et al. Phys. Plasmas **22** (2015) 056108.
[3] Y. P. Zhang, Y. Liu, X.Y. Song, et al. Rev. Sci. Instrum. **81** (2010) 103501.
[4] P. V. Savrukhin, Rev. Sci. Instrum. **73** (2002) 4243.

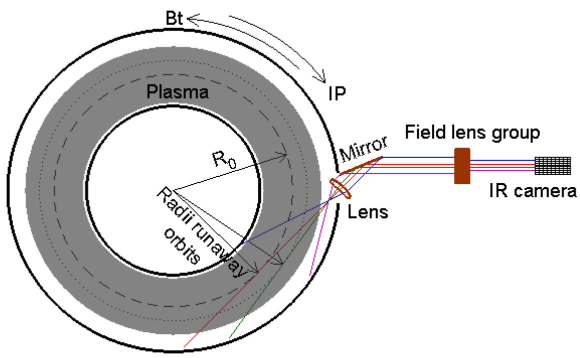

Figure 1. *Sketch of infrared periscope system on HL-2A, as well as the directions of magnetic field and plasma current.*