# Direct measurement of SOL helical current filament induced by lower hybrid wave and its application on edge localized mode control

S.C. Liu[1,2], Y. Liang[2,3], R. Ding[2], M. Jia[2], N. Yan[2], M.H. Li[2], W. Y. Wei[2,3], L. Liao[2,3], S. Xu[3], G.S. Li[2], R. Chen[2], G.H. Hu[2], X.J. Liu[2], X. Han[2], Y. Sun[2], Q. Zang[2], J.P. Qian[2], G.Q. Li[2], L. Wang[2], G.S. Xu[2], X.Z. Gong[2], X. Gao[2] , F.C. Zhong[1], and EAST Team

[1] College of Science, Donghua University, [2] Institute of Plasma Physics, Chinese Academy of Sciences, [3] Forschungszentrum Jülich GmbH. Email: scliu@dhu.edu.cn

A new directional electron probe (DEP) has been developed to measure the edge non-thermal electron current in magnetically confined plasma, and the corresponding principle of DEP is demonstrated by a particle orbit simulation and experiments in EAST [1, 2]. Lower hybrid current drive (LHCD) is an efficient method to drive plasma current and control current profile. Strong mitigation of edge localized mode (ELM) has been observed in the lower hybrid wave (LHW) modulation experiment on EAST tokamak [3], and the edge magnetic topology change induced by the scrape-off layer (SOL) helical current filaments (HCFs) caused by LHW is proposed as a possible mechanism[4, 5]. In the previous publications, it is challenging to build a precise physical model for the ELM control by using LHW without direct measurement of the HCFs. Recently, a series of experiments have been performed in EAST to measure the HCFs induced by LHW with the DEP. One of the four HCFs driven by the 4.6 GHz LHW antenna covers a radial region over 20 mm with a maximum current density of about 20 A/cm$^2$. The dependence of HCFs on the plasma density and $q_{95}$ are studied in these series of experiments. There is a density threshold for the excitation of the LHW SOL current. The current density of HCF is relatively small in low line-averaged density discharges, but it increases significantly when the density reaches a threshold around $\bar{n}_e = 2.8 \times 10^{19}$ m$^{-3}$, and then it continuously increases with the density. This experiment observation confirms that the SOL HCF is higher in larger density cases, which could be extremely important for large fusion devices, such as ITER, because the LHW could drive large SOL current and modify the edge magnetic topology. The HCFs of LHW are shifted continuously in the poloidal direction via decreasing the plasma current and increasing $q_{95}$ simultaneously, which reveals a long poloidal elongation length of the HCF. The three-dimensional HCF is reconstructed by the field line tracing analysis based on the SOL current measured by DEP, which is essential for building a precise physical model of LHW HCFs. The cross-field transport is also measured by four Langmuir probe pins on the front surface of DEP, exhibiting strong enhancement of radial transport during the application of LHW. The dynamic evolution of the radial transport and the corresponding edge plasma parameters are analyzed to give a complete physical picture of radial transport caused by LHW. In this contribution, the three-dimensional structure of HCF caused by LHW is measured directly, and its dependence on some key parameters (plasma density and $q_{95}$) are also identified. Based on our investigation, a successful ELM suppression experiment is achieved within a $q_{95}$ = 5.5-6.5 window in 2023.

## References

[1] Liu S. C. et al 2021 Nucl. Fusion 61 126004
[2] Liu S. C. et al 2021 Nuclear Materials and Energy 29 101080
[3] Liang Y. et al 2013 Phys. Rev. Lett. 110 235002
[4] Rack M. et al 2014 Nucl. Fusion 54 064016
[5] Xu S. et al 2018 Nucl. Fusion 58 106008

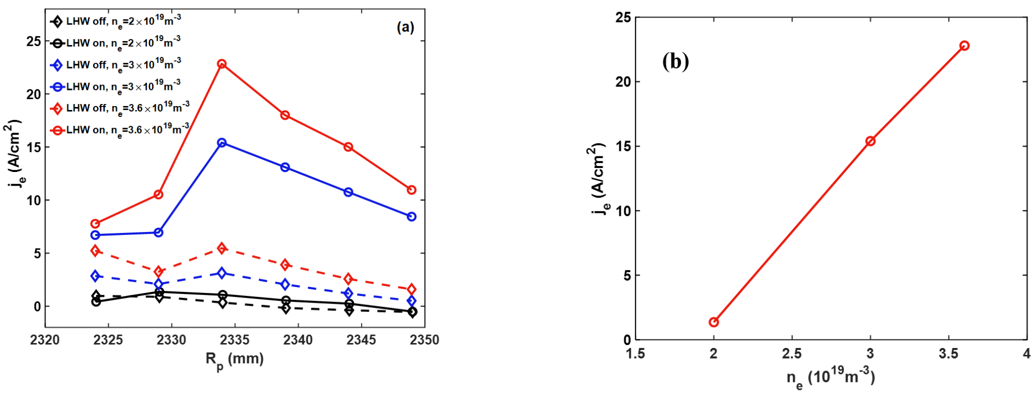


Figure 1. (a) The radial distribution of SOL current during LHW wave modulation; (b) the dependence of SOL current induced by LHW on plasma density.