Determining the electron transport mechanisms from direct heat flux reconstructions

M. van Berkel[1,2], T. Kobayashi[3], G. Vandersteen[2], H.J. Zwart[4], H. Igami[3], S. Kubo[3], N. Tamura[3], M.R. de Baar[1,4], and the LHD Experiment Group

[1]*Dutch Institute For Fundamental Energy Research (DIFFER), PO Box 6336, 5600HH Eindhoven, The Netherlands*

[2]*Vrije Universiteit Brussel (VUB), ELEC, Pleinlaan 2, 1050 Brussels, Belgium*

[3]*National Institute for Fusion Science, 322-6 Oroshi-cho, Toki-city, Gifu, 509-5292, Japan*

[4]*Eindhoven University of Technology, ME, PO Box 513, 5600MB Eindhoven, The Netherlands*

Confinement in fusion devices is largely determined by the transport mechanisms in electron transport, which is generally described by the heat equation

$$\frac{\partial}{\partial t}\left(n_e T_e(\rho,t)\right) = \nabla_\rho\left(-q_e(\rho,t)\right) + p(\rho,t), \qquad (1)$$

where $T_e(\rho,t)$ is the electron temperature, ρ the normalized radius, n_e the electron density, and $p(\rho,t)$ the heating power density. The heat flux q_e dependencies on the diffusivity χ_e, convective velocity V_e, critical gradients, power dependence, etc., is crucial in understanding what drives transport. However, as the heat flux cannot be directly measured and q_e is a time and space-dependent quantity, we must identify q_e implicitly. The standard approach is to pre-define the heat flux dependencies [1]. Therefore, standard forms such as $q_e = -n_e\chi_e\nabla_\rho T_e - n_e V_e T_e$ are used to identify the heat flux. Casting the heat flux in a specific dependence allows the estimation of the time invariant quantities χ_e and V_e. However, it also poses a danger as we made an assumption of the heat flux structure. We propose an alternative approach by combining the heat flux reconstruction in [2] and advanced frequency domain signal processing techniques to directly estimate the heat flux q_e [3]. The experimental result is shown in Fig. 1, which can be used to estimate, e.g., diffusion coefficient χ_e via the slopes [3].

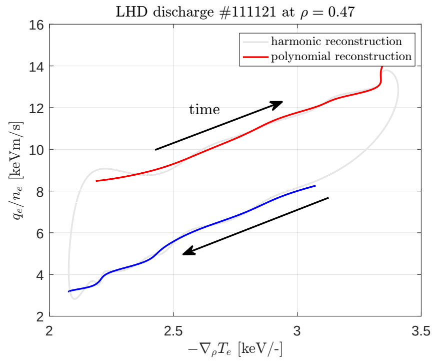

Figure 1: Experimentally determined relative heat flux q_e as a consequence of a block-wave power modulation.

References

[1] M. van Berkel, et al., Phys. Plasmas 21, 112507, 2014.

[2] S. Inagaki, et al., Nucl. Fusion, pp. 113006, 2013.

[3] M. van Berkel, T. Kobayashi, et al., (submitted to) Plasma Phys. Control. Fusion, 2018.