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Web Seminar

Simultaneous inference of multiple plasma parameter profiles by utilizing transport properties

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Abstract

Numerical techniques for the computation of a posterior distribution ease restrictions on inference models, and multiple plasma parameters can be simultaneously inferred with detailed modeling of uncertainties[1]. In addition, data that depend on multiple parameters in a complex fashion can also be utilized[2]. This talk introduces the frameworks that further expand the capability of inference by including transport properties in plasmas.

In addition to the smoothness conditions, the particle conservation law given by a transport model provides a prior belief. Specifically, sets of plasma parameter profiles that satisfy the particle conservation law are likely to be true. This information can be utilized as the prior belief within the Bayesian frame. Ref[3] employs a prior probability function that takes large values when the particle source and sink terms are balanced by the divergence of a diffusive particle flux. Through synthetic data analyses, it is shown that one-dimensional profiles of the electron density, electron temperature, and neutrals can be inferred even when only a few line integrated quantities are observable. Furthermore, if local measurements of plasma parameters, e.g. Thomson scattering diagnostic, are available, the diffusion coefficient can be treated as unknown, and estimated together with the other plasma parameters.

The second example[4] considers the measurements of the diffusion coefficient and the convection velocity of impurities in a tokamak plasma. In this case, the profiles of these transport coefficients for a given background plasma can be obtained by solving linear equations. By taking advantage of this low computation cost, the transport coefficients can be directly inferred from data without considering the profiles of

impurities. As is the case with conventional techniques for impurity transport measurements, this inference problem is ill-conditioned. To address this issue, a non-parametric Bayesain approach is employed. In this framework, all spatial points that represent smooth profiles have their own degrees of freedom. Therefore, all solutions that are consistent with data and prescribed smoothness conditions can be considered.

[1] S. Kwak, et.al, Nucl. Fusion, **60**, 046009 (2020).

[2] C. Bowman, et.al., Nucl. Fusion, **62**, 045014 (2020).

[3] T. Nishizawa, et.al., Phys. Plasmas, **28**, 032504 (2021).

[4] T. Nishizawa, et.al, Nucl. Fusion, **62**, 076021 (2022).