Bayesian Inference for the LHD Experiment Data

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Bayesian statistics is becoming more popular in wide range of science. However, its application to the fusion study is still limited except for a few basic studies [1-3]. In this talk, I will present some basics of Baysian methods, a few of recent machine learning methods, as well as our recent applications to the fusion study in Large Helical Devices (LHD).

One of our applications is the estimation and calibration of the systematic noise in Thomson scattering diagnostics for LHD [4]. Classical statistical analysis, which has been adopted for a long time, is effective to consider the *random* noise, however one of its limitations is the difficulty to take *systematic* noise into account. In case of Thomson scattering diagnostics, the uncertainty of the sensitivity calibration makes additional scatter in the observation. We have modelled such a systematic noise within one of Bayesian statistical frameworks, Gaussian process regression. From a large set of observation data by Thomson scattering diagnostics and the statistical modeling, we have separate the observed signal into the latent plasma parameters, random noise, and the systematic noise. This inference techniques decreases the scatter in the electron density inference by factor of 5 and revealed small spatial structures of electron density distribution in LHD.

Another our application is the atomic data evaluation related to highly charged tungsten ions [5]. Based on large experimental data for the near-ultraviolet emission line intensity of highly charged tungsten observed from LHD plasmas, we derived the electron temperature dependence of the fractional abundance for charge states of 23-28 and the spatial profile of the tungsten density. Since this result purely comes from experiment, it could be a benchmark for the future theoretical calculation.

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