Inverse problem in the estimate of the internal current density of the interchange mode from the magnetic probe measurement in LHD

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In the next generation fusion experiments, such as ITER, the effects of the radiation from the fusion reaction on diagnostics are significant. For example, detailed measurement using semiconductor-based detector cannot be used in such devices, since the noise from the neutron / gamma-ray is not negligible and the detectors will be easily damaged. Estimation of the physical parameters inside the plasma from the indirect measurements is thus required.

This estimation is a kind of inverse problem. Even though the relation of the physical parameter and the measured signal is complicated, it basically is a linear in many cases. Analysis method developed for the data-science, which is significantly improved recently, due to the requirements of the machine learning technology, is quite useful for this kind of problem. Parameters in the linear regression problem are stably estimated using regularization schemes. Here, one practical example, where the internal fluctuation current density due to the interchange mode, is estimated from the magnetic fluctuation data measured outside the plasma, is introduced.

Fig. 1 shows the schematic arrangements of the internal current and the magnetic probes. Since the eigenfuction of the interchange mode is known to be quite localized around the rational surface, the current can be modelled to be sheet-like current having poloidal-angle variations. The rotation of the plasma makes the oscillations. In this problem, the poloidal current density profile is estimated from the one cycle of the experimentally measured magnetic fluctuations, whose waveform is far from simple sinusoidal wave (fig. 3). This characteristic wave form is well reproduced using the peaked poloidal current profile shown in Fig. 2. Ridge type regularization is used here. Inverse problems appeared in the fusion plasma diagnostics will be also discussed in the presentation.

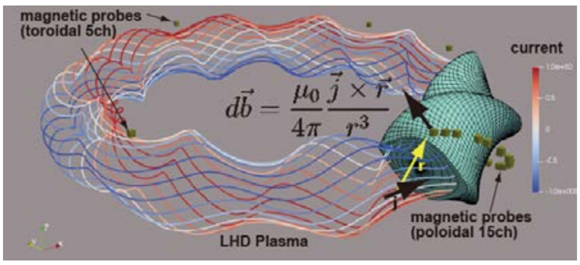

Fig. 1: Schematic drawing of the relation of internal currents and the magnetic measurements of the Large Helical Device (LHD).

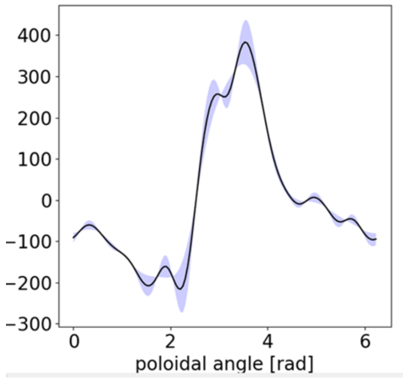

Fig. 2: Estimated current density profile as a function of the poloidal angle.

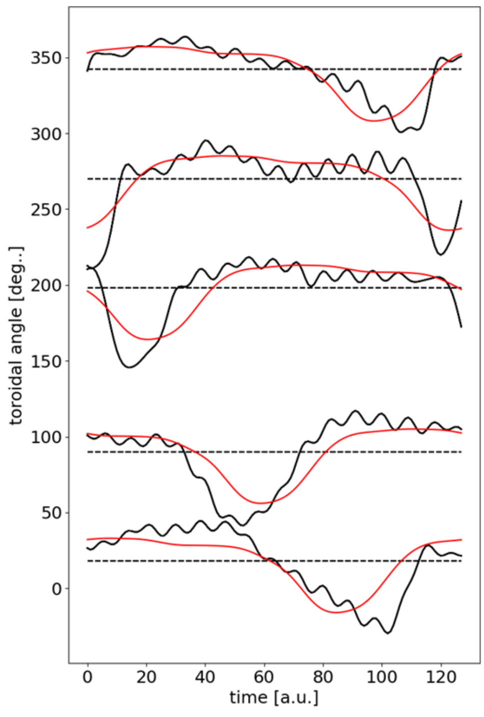

Fig. 3: Measured magnetic fluctuation (black-line) and the estimated signal (red-line) using the current density profile shown in Fig. 2. These irregularly shaped fluctuations are sometimes observed after the ice-pellet injection. It is believed that the interchange mode becomes unstable from the peaking of the density profile after the pellet injection.

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