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Edge Soft X-ray Imaging and Inversion Techniques for Measurement of Magnetic Topology from External 3-D Magnetic Perturbations*

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A new tangential 2D soft x-ray imaging system (SXRIS) has been designed for DIII-D to directly measure the edge island structure in the lower X-point region [1]. Plasma shielding and/or amplification of applied resonant magnetic perturbations (RMPs) may play a role in the suppression of edge localized modes (ELMs). Measurements of the actual island structure inside the plasma are needed to validate models for the effects of RMPs on ELM stability. Soft x-ray (SXR) imaging yields information on the magnetic topology of the plasma and this diagnostic is well placed to advance 3D tokamak physics, especially during RMP ELM suppression. This diagnostic targets the capability to image islands with widths >2 cm near the X-point where the flux expansion is large and island sizes are increased. Core MHD studies have used tangential viewing with visible cameras, pinhole optics and a scintillator plate [2] on both tokamaks and stellarators, but interpretation of the images is complicated by the 3D chordal integration, and requires advanced inversion techniques [3].

The image inversion is ill-posed and is inherently composed of limited-angle measurements. Therefore, it requires a regularization method. This problem has similarities to medical imaging, where high spatial resolution from limited-angle measurements is needed. Bayesian-statistics are often used to determine information at the desired level of accuracy to make useful diagnosis. Our approach is to exploit advances in this field along with more standard techniques used in SXR data of high temperature plasmas, e.g. Phillips-Tikhonov and maximum entropy methods. These techniques add a tailored 'cost function' in the minimization functional, which apply criterion during the minimization.

We use both synthetic modeling of the DIII-D design and the wide-field SXR camera on NSTX to test inversion schemes. The synthetic DIII-D diagnostic calculation is based on 3D SXRIS emissivity estimates calibrated against the NSTX SXR camera [4]. The inversion methods are examined in the context of noise, spatial sensitivity and symmetry assumptions. Models of typical DIII-D discharges indicate integration times >1 ms with accurate equilibrium reconstruction are needed for small island (<3 cm) detection. Inversions of core NSTX 2/1 islands provides a basis to test these methods on less complicated data. These modes are much larger and have clear signatures on other diagnostics. Island sizes measurements are compared to modeling.

[1] M.W. Shafer, et al., Rev. Sci. Instrum. **81**, 10E534 (2010).
[2] Von Goeler, et al., Rev. Sci. Instrum. **70**, 599 (1999).
[3] S. Ohdachi, et al., Plasma Sci. Technol. **8**, 45 (2006).
[4] D.J. Battaglia, et al., Rev. Sci. Instrum. **81**, 10E533 (2010).

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