Research Progress of the Polarimeter/Interferometer on the EAST and BEST Tokamak

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The polarimeter/interferometer is a core diagnostic for measuring electron density and current density profiles in tokamak plasmas. This report presents recent progress of the POINT (POlarimeter-INTerferometer) system on the EAST tokamak, along with its application to the physical design for the future burning plasma device BEST.

The EAST-POINT system employs the three-wave technique with a 432.5 μm far-infrared laser, providing 11 horizontal chords in a double-pass configuration. It simultaneously measures line-integrated density and Faraday rotation angle with a temporal resolution of 1 μs. Error analysis confirms that Cotton-Mouton effect, finite-temperature effect, geometric phase error, and refraction are negligible or have only minor impacts within the EAST parameter range. The system enables vertical displacement monitoring, disruption warning, and density fluctuation measurements.

A ray-tracing-based POINT diagnostic model has been developed and implemented within the IMAS integrated modeling framework. The model uses EFIT equilibrium reconstructions and density profiles to self-consistently calculate line-integrated density and Faraday rotation angle along the actual beam path. Validation on EAST includes a forward–backward closed-loop test: forward-model predictions agree with experimental measurements within 5% for most channels, and reconstructed density and q profiles closely match the input profiles. The model also benchmarks well against the ITER TIP model.

For the BEST device (Q=1 scenario: Ip=5.3 MA, BT=6 T, Te0=18 keV, ne=7.2×10^{19} m^{-3}), the validated model has been applied to preliminary diagnostic design. A layout combining three horizontal and five poloidal chords is proposed, enabling vertical displacement monitoring and current profile reconstruction. Two candidate wavelengths, 10.6 μm and 118 μm, are systematically evaluated. While 118 μm is slightly more sensitive to refraction, it provides Faraday rotation signals about two orders of magnitude stronger, making it the preferred choice for robust magnetic-field inference. The model has been further extended to include finite-temperature and Cotton-Mouton effects. Under the BEST Q=1 scenario, the finite-temperature correction is about 2%–3% for core chords, and the Cotton-Mouton contribution remains below 1%, both within acceptable limits, confirming the robustness of the diagnostic approach.

This work provides a physical foundation for the engineering design of the POINT system on BEST and offers a versatile tool for diagnostic design in future burning-plasma devices.

[1] Chen J et al 2014 Rev. Sci. Instrum. 85 11D303

[2] Liu H Q et al 2016 Rev. Sci. Instrum. 87 11D903