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Design of Collective Thomson Scattering system on Keda Torus eXperiment (Reverse Field Pinch machine in China)

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Collective Thomson scattering (CTS) is a powerful diagnostic technique with the capability to provide bulk ion temperature and ion composition of plasma with high temporal and spatial resolution. It has been developed in many fusion devices such as ASDEX, TEXTOR, W7-X, and ITER etc.
CTS is the elastic scattering process of electromagnetic waves by electrons with collective motions. For CTS diagnostic system in fusion plasmas, the frequency of probe beam is usually set in millimeter-wave band in order to satisfy the condition that Salpeter parameter $\alpha = 1/|\vec{k}_\delta|\ \lambda_D$ exceeds unity. Here, λ_D represents the electron Debye length, while $\left|\vec{k}_\delta\right| \approx \left(4\pi \sin\frac{\theta}{2}\right)/\lambda_0$ denotes the differential scattering vector number, λ_0 is the probe wavelength, and θ is the scattering angle.
Due to the extremely small scattering cross section, high-power pulsed source providing the probe beam and high-sensitivity electronics module receiving the weak scattering radiation are two key issues for CTS. A plused gyrotron source with peak power 1MW/center frequecy 60GHz/pulse length 5us has been built. In the bench test, the source demonstrated excellent repeatability and monochromaticity with a linewidth around 0.2MHz, which provide a solid foundation for the subsequent CTS development. The central frequency is deliberately chosen to be 60 GHz, which can effectively avoid the interference of electron cyclotron emission in the KTX device and improve the signal-to-noise ratio. In terms of the receiving module, diverging from the conventional signal - processing architecture in which mixing followes by amplification, our approach is to implement amplification prior to mixing. This technical pathway has notably enhanced the sensitivity of the intermediate - frequency receiving system. Specifically, a gain of no less than 40 dB has been attained, and the minimum detectable signal amplitude is approximately -65 dBm.
An improved genetic algorithm with the new fitness function has been developed to decompose CTS scattering spectra, which significantly reduces the dependence of the CTS data processing on the information of other plasma parameters.

Keyword-1

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Keyword-2

ion temperature

Keyword-3

fusion plasma

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