Development of high-repetition and high-spatial-resolution Thomson scattering measurement system for elucidating transient plasma phenomena

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In the realm of fusion plasma diagnostics, laser Thomson scattering systems are standard instrumentation for measuring electron temperature and density profiles. However, typical pulsed lasers used for probing are limited to low repetition rates of a few tens to hundreds of Hertz because of heat generation constraints in the laser medium. Consequently, capturing millisecond-order temporal changes in electron temperature and density profiles, such as those caused by hydrogen pellet ablation, plasma collapse, or intense plasma heating, has been difficult or impossible. Our work introduces a high-temporal-resolution Thomson scattering system that measures at rates up to 20 kHz, employing a novel pulse-burst Nd:YAG laser system that produces 1-2 J, 20 ns laser pulses at 1064 nm. This system, in tandem with custom analog-to-digital converters for data recording, enables measurement of electron temperature and density in the LHD stellarator at 70 spatial points, with a 20 kHz repetition rate for 100 temporal frames. This system outperforms typical Thomson scattering diagnostics, enabling the direct observation of transient phenomena like hydrogen pellet dissolution [1], plasma collapse events [2], and the effects of ECH and transient MHD. In addition, a recent development effort increased the repetition rate of the laser system up to 40 kHz. This unique Thomson scattering measurement system has expanded research capability at LHD, and continues to be applied to new plasma physics investigations.

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