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The potential of collective Thomson scattering measurements in burning-plasma devices

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As we approach the era of burning fusion plasma experiments, the ability to monitor and control the conditions in the plasma core becomes increasingly important. The versatility and reactor relevance of collective Thomson scattering (CTS) makes it an attractive option for diagnosing thermal and energetic confined ions in the core of burning plasmas. Here we review ongoing work related to the diagnostic design and measurement potential of CTS at ITER, DEMO, SPARC, and STEP. At ITER, CTS will measure fusion-born alpha particles in 7 spatial locations, for energies from their birth energy to thermalization, and the diagnostic design is now approaching the manufacturing stage. A 2-view CTS diagnostic design for EU DEMO in the new low aspect ratio configuration is being developed for measurements of core toroidal rotation, ion temperature, alpha density, and D/T fuel-ion ratio. At SPARC, CTS measurements can additionally help to monitor the core content of He-3, used as a minority species for ion heating. In contrast to these cases, which would all operate below the fundamental electron cyclotron resonance frequency throughout the plasma, initial studies for STEP suggest challenging conditions for microwave-based CTS on this device, although these might be overcome using a THz-range vertical forward-scattering setup. We also briefly comment on possibilities for CTS at additional devices including JT60-SA, the largest non-burning plasma experiment, and discuss ongoing efforts to enable rapid inference of CTS-relevant plasma parameters for reactor control purposes using machine learning.

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