Collective Thomson Scattering on W7-X: What can we do about those ions?

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The Principle of Collective Thomson Scattering

Process can be divided into several parts:

1. Probing wave is launched into the plasma
2. Several quantities in the plasma fluctuate
3. Incident wave interacts with the fluctuations giving rise to currents
4. Induced currents give rise to the scattered field
5. A part of the scattered field reaches the receiver producing the CTS signal

\[ \alpha = \frac{1}{k^q \lambda_D} > 1 \]

Figure taken from: Moseev et al., Plasma Physics and Controlled Fusion, 53(10), 105004 (2011)
What can you measure?

The collective Thomson scattering spectrum contains information on the *ion dynamics*:

- Bulk ion temperature
- Fast ion velocity distribution
- Plasma composition and fuel ratio
- Density
- Transport
Example – plasma composition

\[ \omega = \frac{qB}{m} \]

![Graph showing plasma composition with Deuterium and Hydrogen lines.](graph.png)
Applications outside of nuclear fusion

- Detection and characterization of Hall thruster instabilities:
  - Potential major impact on thruster performance and design

- EUV plasmas for semiconductor industry:
  - Efficiency of EUV light production depends on the plasma parameters

Figure borrowed from Raymond Liang, The Combination of Two Concentric Discharge Channels into a Nested Hall-Effect Thruster, The University of Michigan, PhD dissertation (2013)
1) Collective Thomson scattering is a powerful plasma diagnostic and the only option for diagnosing the ion populations in the core of a fusion plasma

2) It has applications outside nuclear fusion, we have mentioned two important examples:
   
a) Hall thruster characterization
   
b) Optimization of EUV sources

3) It is a potential money saver for both the space propulsion industry and the integrated circuits industry