Abstract

A new far-infrared (FIR) polarimeter diagnostic for the TCV tokamak is under construction at CRPP.

• It uses two FIR lasers at 432.5 microns, optically pumped by a 120W continuous wave CO₂ laser.

• The two FIR cavities will be detuned such that the combination of the beams, using a method proposed by Dodel and Kunz[1], produces a single beam with a linear polarization rotating at the difference frequency (set to 750kHz).

• Not influenced by signal amplitude variations. Need only one detector per line of sight. 10 lines of sight to cover the plasma radius.

• Faraday rotation angles will be measured by coherent detection.

• Designed especially to obtain current density profiles measurements on low nₑ, low Iₑ plasmas.

Wavelength selection

Due to the wide range of plasma shapes, positions and sizes accessible on TCV, optimal polarimeter measurements for all possible configurations cannot be fulfilled by one wavelength.

• Its design has been guided by the need to have valid q profile measurements in low plasma current Jₑ(100kA) and electron density nₑ(nₑ<1e19m⁻³) ITB plasmas.

• In such discharges, the resolution of the diagnostic has to provide distinguishable Faraday rotation profiles for both monotonic and reversed q profiles.

Laser description

<table>
<thead>
<tr>
<th>Laser type</th>
<th>CO₂</th>
<th>FIR</th>
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</thead>
<tbody>
<tr>
<td>Gaz</td>
<td>8% CO₂, 18% N₂, re He</td>
<td>Formic acid HCOOH</td>
</tr>
<tr>
<td>Nbr of cavities</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Emission line</td>
<td>9.27μm (λ=4.27μm)</td>
<td>432.5μm</td>
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<tr>
<td>Output polarization</td>
<td>Linear vertical</td>
<td>Linear vertical</td>
</tr>
<tr>
<td>Output power/cavity</td>
<td>120W</td>
<td>50mW</td>
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</tbody>
</table>

• Refraction effects scale with λ²

• Faraday rotation amplitude scales with λ²

Faraday rotation theory

In the interferometric domain (ω₁=5ω儆, ω₂=5ω儆), the refractive index N is given by a simplified version of the Appleton-Hartree formula:

\[ N = \frac{\Delta N_{\rho}}{2} \sin^2 \theta \]

\[ \Delta N_{\rho} = \frac{\Delta n_{\rho,0}}{2} \sin^2 \theta + 4 \cos^2 \theta \]

For each of the two values of N a unique eigenstate of polarization can be associated.

• Waves can only travel through the plasma in one of these polarization states, experiencing the corresponding N.

• For instance, for k // B (h=0), the eigenstates are left and right hand circularly polarized waves.

Simulations

• Very low plasma current Jₑ<80kA and electron density nₑ<1e19m⁻³ plasmas

• Compare the Faraday rotation profiles ψ(q) between monotonic and two reversed q profiles.

• Refraction effects will be small.

• With a maximum Y=10, the resolution of the system is going to be close to marginal.

• Distinctions between the two reversed profiles is going to be difficult.

• The slope of ψ around the plasma axis being proportional to the central current density, the central value of q should still however be measurable and distinguishable in between the different q profiles.

References


Acknowledgements

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