Abstract

The goal of this project was to build a wide band receiver that would be capable of detecting rapid non-Maxwellian bursts in plasma temperature. The receiver measures electron cyclotron emission (ECE) from magnetized plasmas. These rises in electron temperature can be related to instabilities in the plasma. The receiver built in this project was tested on the Maryland Centrifugal Experiment (MCX).

Theory

Optically thick plasmas in thermal equilibrium emit black body radiation according to the following formula:

- Hot electrons are produced when the plasma becomes unstable during interchange and other MHD instabilities.
- Electrons orbit around the magnetic field lines and radiate at the electron cyclotron frequency given by

ECE Receivers

Basic Parameters of ECE Receivers

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Ka Band</th>
<th>Ku Band</th>
<th>X Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>30-35GHz</td>
<td>12-18GHz</td>
<td>8-12GHz</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Linear gain</td>
<td>24mV/dB (logarithmic)</td>
<td>24mV/dB (logarithmic)</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>~30dB</td>
<td>100dB</td>
<td>100dB</td>
</tr>
<tr>
<td>Noise Level</td>
<td>-50dBm</td>
<td>-90dB</td>
<td>-90dB</td>
</tr>
</tbody>
</table>

Schematic of Receiver KA and KU/X Band Receivers

Experimental Results

Conclusion

The receivers measured a mean electron temperature that is consistent with MCX theory and optical interferometer measurements. Interchange instabilities in the plasma were shown to generate electron temperature ~4x higher than the mean value. The m = 2 plasma mode was detected. The ECE receivers were able to detect changes in the electron temperature that correlate well with plasma voltage and DML data.

Discussion

- Conjectures
  - Receivers are possibly detecting harmonics of the fundamental electron cyclotron frequency
- Improvements to Receiver
  - Construct a multichannel receiver to simultaneously measure ECE radiation at different frequencies and positions
  - Analyze multichannel data using auto and cross correlation techniques
  - Use a wide band oscilloscope to directly digitize the intermediate frequency signals in quadrature mode
- Future Work
  - It is feasible to apply diagnostic to extremely energetic plasmas such as magnetic reconnection and plasma focus experiments
- Acknowledgments
  - MCX Group
  - William Young, Carlos Romero Talamás, Catalin Teodorescu