Plasma II - Exercises

Dr. H. Reimerdes, Dr. E. Tonello - EPFL/SPC

Problem Set 13 - May 30, 2025

Interferometry on TCV

Interferometry is commonly used to measure the plasma density. TCV is equipped with a multi-channel system that uses a far-infrared difluoromethane (CH_2F_2) laser emitting at $\lambda = 184.3\mu$m.

a) What is the upper electron density limit of the diagnostics?

b) What density corresponds to one *fringe*, i.e. the difference in density that leads to the same interference pattern?

c) Derive the expression for the signal a photodiode would detect at *detector 1* (see drawing on slide 18). Assume an ideal geometry with an identical optical path length of the *reference beam* (RB) and the *sample beam* (SB) in the absence of a plasma. Note that photodiodes detect the average intensity of an e.-m. wave. (**Hint:** The average intensity can be obtained from the square of the absolute value of the the electric field using complex notation $\mathbf{E} = \hat{\mathbf{E}}e^{i\omega t}$).

d) Discuss why the signal of detector 1 is not sufficient to provide an unambiguous result. Can the signal of *detector 2* (see drawing on slide 18) help?

e) In TCV the problem raised in d) is solved by superposing SB and RB with a frequency shifted beam, referred to as *local oscillator* (LO), each. The frequency shift with respect to the original laser frequency is achieved with a rotating grating, which applies a shift of $\Delta\omega/(2\pi) = 100kHz$. A schematic of such a *heterodyne* detection scheme is shown in the figure below.

   Derive the expression for the photodiode signal of the superposition of SB and LO (*plasma detector*) as well as of RB and LO (*reference detector*). Both signals are separately acquired. Explain why this resolves the ambiguity.

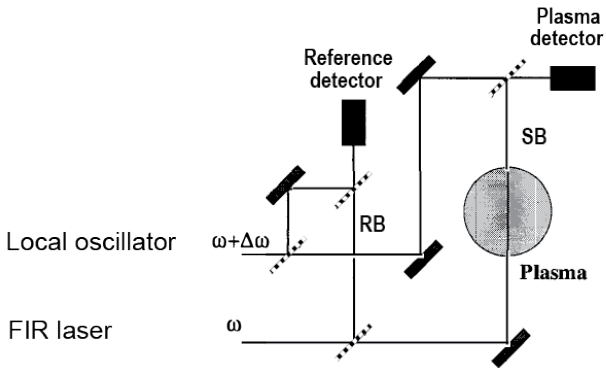

Figure 1: Schematic of a heterodyne interferometer.