Development of tube of quiescent plasma for introduction to waves in plasmas

Ricardo de Ávila Mesquita[1], Gustavo Paganini Canal[2]
Universidade de São Paulo, São Paulo, Brasil[1,2]
ricardo.av.mesquita@usp.br[1], canal@if.usp.br[2]

Introduction

In the initial contact with the field of plasma physics, many gadgets can be used to demonstrate different concepts, and to perform various experiments in the classroom. While such devices are commonplace throughout laboratories around the world, one capability that is as of yet lacking in IFUSP is to visually and/or didactically demonstrate wave effects in plasmas. This work consists in making a quiescent plasma inside a compact tube, preferably with a window for observation, in which it is possible to stimulate it to take stationary electromagnetic wave form (or at least with sine form) under multiple conditions. It will be used in introductory plasma physics courses, focusing on wave effects in plasma (i.e., chapter 4 of Francis F. Chen's "Introduction to plasma physics and controlled fusion"). Moreover, sensors will be implemented inside it so that the wavelength can be determined experimentally.

It is relevant to note that this project was underway until the Covid pandemic put a stop to it. Therefore, there is previous groundwork already developed, and that is still to be studied.

Figure 1: Picture of the hull of the tube

Objetives

Build a quiescent plasma tube that demonstrate EM waves in plasmas that will be used in lectures for educational purposes.

Challenges

- As the structure of the tube is already made, the dimensions are pre-established and cannot be altered.
- EM wavelength must be pre-determined and have the same module for all configurations.
- Sensors must be tuned to the chosen wavelength.
- Creation of EM wave to be studied.
- Display of data acquired by sensor to be studied.
- Toolkit/manual for fast solution of potential problems during the demonstration should be made available, in case it is necessary during lectures.
- As the plasma is quiescent, any destabilizing effect may compromise the entire experiment. As such, the equipment setup must be extremely well tuned, and multiple non-ideal situations are to be expected, so a comfort interval of precision is likewise necessary.
- Magnetic field must be created using **commercial magnets** readily available at the laboratory. Due to their circular shape, non-uniformity of the field is predicted, but must be minimized.

Figure 2: Picture of the magnets that are to be used in making the tube

- **Observation window** requires no magnets attached to it, which contributes to instability in magnetic field.

3D Models

The vessel planned to be used in this project has been measured and modeled using a computer aided design software.

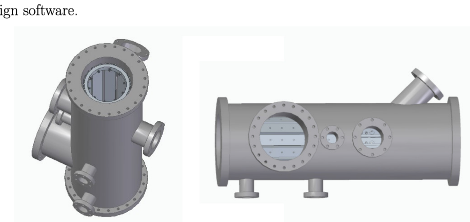

Figure 3: Computerized sketch of the hull of the tube.

A sketch of the basic "cage" structure in which the magnets will be installed has also been designed.

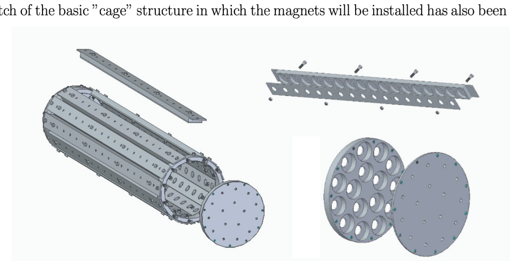

Figure 4: Computerized sketch of where the magnets will be coupled.

Future Developments

2023, early 2024
Create **adequate magnetic field**
Arrange the necessary equipment and procedures to **create vacuum** inside the tube

2024, early 2025
Elaboration of methodology of **stimulating EM waves** in the plasma
Select and install **sensors**
Study how to allow opening for observation window without destabilizing magnetic field

Tube ready to be used in introductory plasma physics lectures
by the second semester of 2025

Acknowledgements

Special thanks to the amazing people at the Plasmas Laboratory in IFUSP for their assistance in the process of making this poster, as well as their previous work on this project.