Examination of the 7th December 2022

Lectures of N. Delerue

All documents allowed

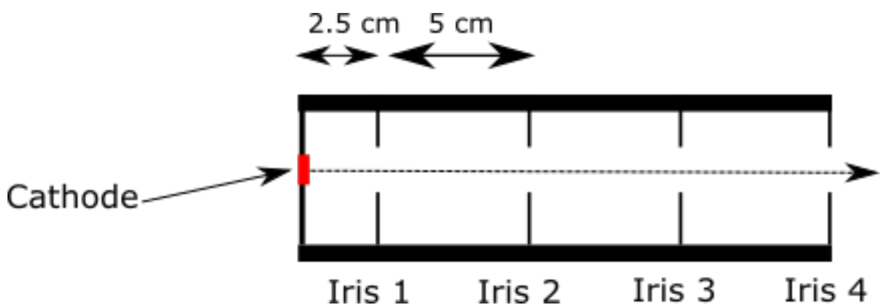
## 1. Lecture questions (9 points)

1.1. What are the three phenomena that are used to extract electrons from matter (3/20)?

1.2. Describe the main elements (at least 5) of an Electron Cyclotron Resonance (ECR) source and make a drawing of such source. (6/20)

## 2. Study of an RF Gun (11 points)

We will consider an RF Gun used as source of electrons. The gun is made of one cell that is 2.5 cm long in which the cathode is located and 3 cells that are 5 cm long. The cells are separated between themselves by irises.




### 2.1. Electrostatic case (1/20):

2.1.1. Let's consider than an electrostatic field of 10MV/m is applied to this gun (the field increases along the path of the particles). This field is oriented so that electrons will be accelerated in the gun. If the cathode is at the ground potential. What is the potential of each of the irises? What is the potential at the exit of the Gun? (0,5/20)

2.1.2. An electron is emitted at the cathode. What will be its energy (in kilo electron-volts) at each of the irises and at the exit of the gun? (0,5/20)

### 2.2. Field varying with position (3/20):

Let's now replace the static field with a time dependant electric field of the form:
E(s)=E0 sin (k s + x0)
where E0 is the field amplitude, k is a constant, s is the horizontal coordinate of the particle, x0 is a constant.
We will take E0=100MV/m.

2.2.1. Calculate the value of the constants k and x0 so that the value of the field described above is 0V/m both in the first and in the second iris (1/20).

2.2.2. What is then the value of the field at the cathode (1/20)?

2.2.3. An electron is emitted at the cathode with the values calculated above for the constants. What will be its energy at the first iris? What will happen after the first iris? Will it reach the exit of the gun? (1/20)

### 2.3. Field varying with position and time (7/20):

Let's now consider a field varying both time and position:
E(s,t)=E0 sin (k s + x0) * sin (w t + phi)
where w and phi are two constants (the other variables have the same meaning than in the previous case).
We assume that the electrons travel at the speed of light.

2.3.1. Calculate the value of w so that an electron travels the distance between two irises during one period of sin (w t) (1/20).

2.3.2. As the electrons are travelling at the speed of light, the variable s and t are correlated. Express t as a function of s and rewrite E(s,t) using only the coordinate s (1/20).

2.3.3. Let's assume phi = 90 degrees. An electron is emitted at the cathode at t=0. Using the above formula, what will be its energy at each of the irises and at the exit of the gun? (1/20)

2.3.4. Do the same calculation for phi = 0 degrees, phi=45 degrees, phi=135 degrees and phi = 180 degrees (2/20), using these values draw the final energy as function of phi (1/20) and comment on these results (1/20).