UNIVERSITÉ PARIS SUD Comprendre le monde, construire l'avenir®	**MASTER 2 – GRAND INSTRUMENTS**	université PARIS-SACLAY

Examination of the 7th November 2017

Lectures of N. Delerue

All documents allowed

Reminders

The Richardson formula given in the lecture reads as follow:

$$J = A_G T^2 e^{-\frac{W}{k_B T}}$$

$$A_G = \lambda_R A_0$$

$$A_0 = \frac{4\pi m k^2 e}{h^3} \sim 1.2 \times 10^6 Am^{-2}K^{-2}$$

The value of the Boltzmann constant is 8.6 10^{-5} eV.K^{-1} .

A 500nm photon has an energy of 4x10^{-19}Joules.

The Child-Langmuir formula given in the lecture reads as follow:

$$J = 2.33\,x\,10^{-6} S \frac{V^{3/2}}{d^2}$$

J is the current, s the area, V the potential and d the distance.

1 Coulomb = 6.28 10^{18} electrons

1. Lecture questions (9 points)

1.1. Cite three processes through which a neutral atom in gaseous state can become ionised and discuss their relative cross section. (4/20)

1.2. Describe the main elements (at least 5) of an Electron Cyclotron Resonance (ECR) source. (5/20)

2. The PHIL and CLIO accelerators (11 points)

2.1. The accelerator PHIL uses an RF gun as electron source whereas the CLIO accelerator uses a thermionic gun. Compare the properties of the electrons produced by these sources. Your comparison should at least comment on the following points:
- Electrons energy and energy spread?
- How to produce high charge bunches? How easy is it in each case?

- How to go to a high repetition rate? How complicated is it in each case?
- For these two sources, explain how the bunch length can be controlled? (4/20)

2.2. Let's consider a photoinjector using a laser with a power of 1MW during 1ps. The laser radiation is emitted at a wavelength of 250nm. The cathode has a quantum efficiency at 250nm of 10^{-4}. What is the charge of the bunch produced by each laser pulse? (2/20)

2.3. Now let's consider a thermionic gun operating with a titanium cathode (let's assume that the cathode has a work function of 4.3eV). The size of the cathode is 5mm x 5mm, it is at a potential of 50kV with a 100mm gap between the cathode and the anode. It is heated to a temperature of 2700K. What is the current produced by this cathode? Suggest a mechanism that could be used to limit the cathode emission to 100ps at a time. What would be the charge emitted per bunch in that case? (3/20)

2.4. To increase the emission one could increase the operating temperature of the thermionic gun described above. What would be the limit current that could be reached by increasing the temperature? Why? (2/20)