Publ. Astron. Obs. Belgrade No. 84 (2008), 107 - 110 *Contributed Paper*

SELE HEM: ADJUSTING THE PARAMETERS

D. ŠEVIĆ[1], A.R. MILOSAVLJEVIĆ[1], I. ČADEŽ[2]
and B. P. MARINKOVIĆ[1]
[1] *Institute of Physics, Belgrade, Serbia*
E–mail: sevic@phy.bg.ac.yu
[2] *Institut Jožef Stefan, Ljubljana, Slovenia*

Abstract. This paper presents preliminary results of adjusting parameters of Hypocycloidal Electron Monochromator in Stepwise Electron Laser Excitation (SELE) experiment at the Institute of Physics, Belgrade.

1. INTRODUCTION

In our SELE experiment the cylindrical electron monochromator (see Marinković et al. 1992) is utilized for low energy (0.3-20 eV) electron beam formation. Crossed magnetic and electric field in cylindrical symmetry are used to select the electrons having energy in the narrow interval. For this kind of monochromator, the uniform magnetic field is one of the basic requirements. Because of the large range (20 cm) in which uniform magnetic field is required in our experiment, the most common solution of using Helmholtz pair (because of large dimensions of coils) has been abandoned. Our five-coil system is described in Marinković et al. 2006 and Šević et al. 2008.

In this paper we describe preliminary results of adjusting the parameters of our cylindrical monochromator. Simultaneously with assembling the apparatus, we did SIMION simulations to have some insight into behavior of electrons, i.e. to have some starting values of electron optics voltages. We have obtained the electron beam in the target area by playing it by ear, i.e. optimizing the HEM electrodes voltages by manually turning the knobs, guided by readouts of digital electrometer measuring the beam current. Magnetic field was 30G, obtained by setting coil currents to the values from numerical calculation and verified by measurement with Gaussmeter. Slight tunning of currents with respect to the predicted values was needed in order to maximize output beam current.

Our monochromator was called cylindrical (cylindrical trochoidal electron monochromator, CTEM, Marinković et al. 1992), because of geometry of the electrodes. In (Smialek at al. 2005) and (Smialek at al. 2007) the same type of monochromator is called hypocycloidal electron monochromator (HEM) because of the shape of electron trajectories. From now on, we will use the name HEM, also. First, we will shortly review the theoretical basics of HEM as presented in Smialek at al. 2005. Then, we will present some preliminary results of our SIMION simulations of HEM. Finally, we will describe some of the first adjustments of monochromator.

2. THE CYLINDRICAL ELECTRON MONOCHROMATOR

In the HEM, the electrostatic field is produced by two cPoaxial cylindrical electrodes, the inner and outer electrodes with radii R_1 and R_2, respectively. The magnetic field is directed along the axis of the HEM. Potential distribution is:

$$V(r) = V_0 - \frac{V_1 - V_2}{\ln(R_2/R_1)} \ln(2r/(R_1 + R_2) \qquad (1)$$

The electrons drift in HEM describing hypocycloidal trajectories on the surface perpendicular to the direction of the magnetic field. The radius of the hypocycloids is about two orders of magnitude smaller than the mean radius $R_0 = (R_1 + R_2)/2$. The electrons drift with a approximately constant velocity:

$$v_d \approx \frac{E_r}{B} \qquad (2)$$

where $E_r = (V_1 - V_2)/(r \ln(R_2/R_1))$ is electrostatic field, and B is the magnetic field strength.

At the exit plane of the monochromator the electrons are deflected by an angle ϕ_d:

$$\phi_d = \frac{LE_r}{Brv_z} \qquad (3)$$

where L is HEM length, and v_z is constant velocity component along the axis of the HEM.

For optimum energy resolution of the HEM, as shown by Smialek at al. 2005, a higher polarization potential should be applied to the inner cylindrical electrode.

In our apparatus, emitting cathode is a thoria-coated iridium filament. Elements of our cylindrical monochromator have names as follows. Potential of the filament center is denoted by V_n. Filament housing is denoted by V_f. First beam forming electrode is V_k. Beam is then focused by electrodes S_1, S_2 and S_3. Entrance and exit electrodes are N_1 and N_2, respectively. Between N_1 and N_2 are cylindrical electrodes V_1 and V_2. Length of cylindrical electrodes is 126 mm, inner and outer radii are 8.8 mm and 22 mm, respectively. Just before exit aperture on N_2, there is an electrode S_p for collecting nonmonochromated electrons.

Set of the starting electrode voltages was obtained by SIMION simulations.

An illustration of electron trajectories simulation is presented in Fig 1.

3. ADJUSTING THE MONOCHROMATOR

After "guessing" the initial values as determined by SIMION simulations, fine adjustments were made by tuning the electrode voltages.

Electron optics electrode voltages, after optimization, are presented in Table 1.

Two sets (for two combinations of cylindrical electrode voltages) of ilustrative experimental results are presented in Table 2. ICC and OCC denote inner and outer coil current, respectively. IEV and OEV denote voltages of inner and outer cylindrical electrode of HEM. Electron beam current is denoted by EBC. Beam is collected

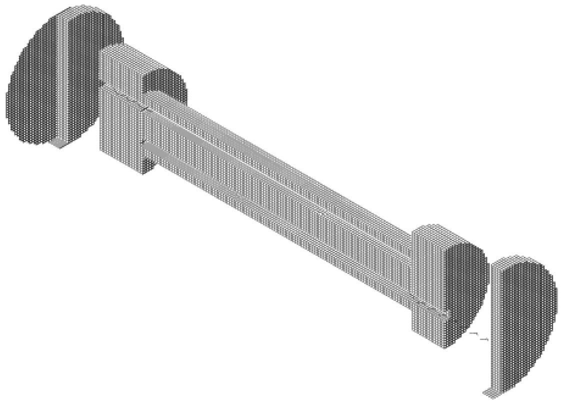

Figure 1: An illustration of electron trajectories simulation.

Table 1: Electron optics electrode voltages.

electrode	voltage [V]
V_n	-13.4
V_f	4.7
V_k	-12.69
S_1	1.32
S_2	5.75
S_3	-7.46
N_1	5.63
N_2	-1.89
S_P	-1.26
V_1	-10.44
V_2	-11.40

by a round electrode (diameter 38 mm) placed in the target area. The electrode is grounded via digital electrometer. All voltages are measured with respect to ground.

Determination of electron beam energy resolution using retarding potentials method is planned in near future.

Table 2: Parameters of HEM and electron beam current(EBC).

IEV [V]	OEV [V]	OCC [A]	ICC [A]	EBC [100pA]
-10.44	-11.40	0.95	1.48	8.5
-10.44	-11.40	0.95	1.57	9.5
-10.44	-11.40	0.95	1.66	10.5
-10.44	-11.40	0.95	1.76	10.5
-10.44	-11.40	0.95	1.85	10.6
-10.44	-11.40	0.95	1.82	10.2
-10.44	-11.40	0.95	1.90	10.1
-10.44	-11.40	0.95	2.00	10.0
-10.44	-11.40	0.95	2.30	8.0
-2.95	-2.10	0.95	0.87	4.9
-2.95	-2.10	0.95	1.01	6.0
-2.95	-2.10	0.95	1.12	8.8
-2.95	-2.10	0.95	1.23	9.4
-2.95	-2.10	0.95	1.41	9.8
-2.95	-2.10	0.95	1.51	11.3
-2.95	-2.10	0.95	1.70	8.0
-2.95	-2.10	0.95	1.80	7.5
-2.95	-2.10	0.95	1.90	5.5
-2.95	-2.10	0.95	2.01	4.6

4. CONCLUSION

We presented the preliminary results of adjusting parameters of our SELE HEM. Although it is relatively easy to obtain the electron beam, the problem of optimization of its characteristics faces us in near future. First of all, electron beam energy resolution should be determined using retarding potential method.

Acknowledgments

This work has been carried out within project 141011 financed by Ministry of Science of Republic of Serbia and bilateral project Serbia - Slovenia 2008-2009 ("Electron induced fragmentation of organic molecules and small hydrocarbons").

References

Marinković, B., Wang, P., and Gallagher, A.: 1992, *Physical Review A*, **46**, No. 5, 2553.

Marinković, D, Milosavljević, A, Marušnik, D. and Šević, D.: 2006, Proceedengs of the 23rd SPIG, August 28 - September 1, Kopaonik, Serbia, pp. 97-100.

Šević, D., Milosavljević, A., Marinković, B.: 2008, Proceedengs of the 1st CEAMPP, 15- 18 May, Zaječar, Serbia, pp. 45-46.

Smialek, M., Dydycz, A., Mielewska, B., Feyer, V. and Zubek, M.: 2005, *Measurment Science and Technology*, **16**, 2275.

Smialek, M., Mielewska, B. and Zubek, M.: 2007, *Radiation Physics and Chemistry*, **76**, 599.