2^{nd} Semester Report

Semester Report 2018/2019 spring

By Tariq Hailat (hailat@caesar.elte.hu)

Doctoral School of Physics-ELTE

Supervisor: Balázs Madas, Radiation Biophysics Group, MTA Centre for Energy Research, Budapest, Hungary.

Ph.D Thesis topic: Modeling of adaptive responses to ionizing radiation at different levels of biological organization.

Place of research: MTA Centre for Energy Research, Budapest, Hungary

Introduction

Radiation includes the entire spectrum of electromagnetic waves: radio waves, microwaves, infrared, visible light, ultraviolet, x-rays and atomic particles. In this research we are concerned with radiation having energies high enough to ionize matter specifically the emissions from radioactive elements such as alpha particles. Ionizing radiation emitted during the radioactive decay can induce a variety of cytogenetic effects that can be biologically damaging and result in an increased risk of carcinogenesis. Most of researchers perform their experiments in radiation biology to estimate the relationship between some biological effects like DNA double-strand breaks (DSBs) or cell survival and radiation dose. In order to determine the risks associated with these doses.

The objective of the research in this semester was to develop the previous python code in order to include many of cells (10000 cells) and many of alpha particles (10000 alpha particles), then to calculate number of hit cells, probability of hitting alpha particles with cells, the absorbed energies and the distribution doses.

Description of research work carried out in current semester

I contributed to count the number of alpha particle tracks on the surfaces of 24 CR-39 detectors using an optical microscope. For each detector, I took about 10 views of the surface of detector. CR-39 detectors were placed to the location of the cells (the upper well of the Transwell® system) (see figure1). Alpha-particles leave a track in CR-39 material (see figure 2). The track diameter can be increased by chemical etching making the tracks visible with an optical microscope. The number of tracks can be counted with or without software developed for track recognition. In the present study, some detectors were evaluated in a computer aided way, while some others were evaluated without using any software. We can use this method to compare the results of CR-39 detectors with the simulation results.

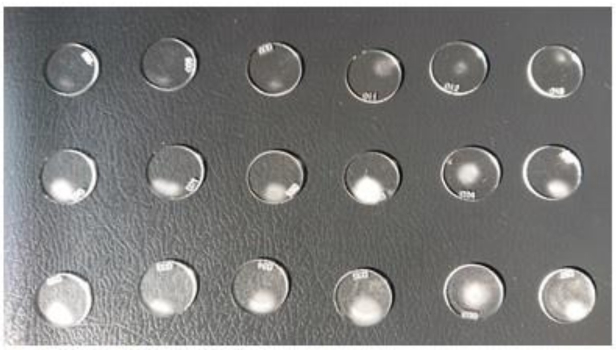

Figure 1. Detectors exposed to a Ra-223 activity of 10 kBq

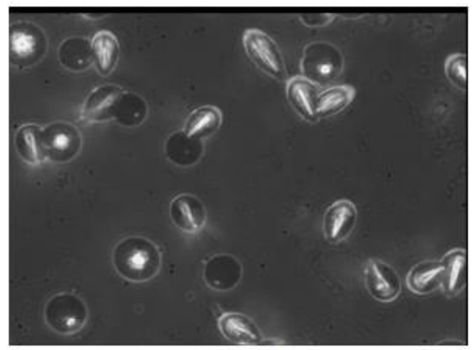

Figure 2. Tracks view of alpha particles from the surface of detector.

Many of blood cells were put them in plastic holder at a distance (D) from the radioactive source (Ra 223) (see figure3). So, the python cod was written to calculate the number of hit cells and find the relation between average numbers of hit cells with average numbers of alpha particles, then find absorbed energy and dose distribution. The Monte Carlo simulation using python code here depends on some conditions:

1- Checking if alpha particles reach to membrane of the cells holder.
2- Checking if alpha particles penetrate the thickness of the plastic membrane.
3- Checking if the alpha particles hit cells: By define the random directions of alpha particles in python code (equations 1, 2, 3) and substitution in the equation of spherical cell (equation 4) we will get the quadratic equation.

$X = X_0 + tV_x$ …………. (1)

$Y = Y_0 + tV_Y$ …………… (2)

$Z = Z_0 + tV_Z$ ………….... (3)

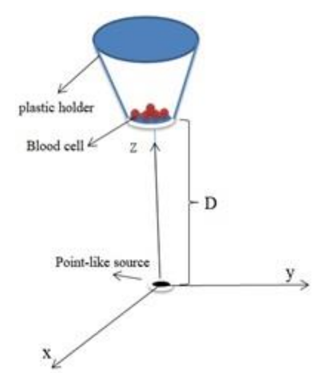

Figure 3. shows that the radioactive source and the cells

$$(X - a)^2 + (Y - b)^2 + (Z - c)^2 = R^2 \ldots\ldots\ldots.. (4)$$

By selection 10000 random positions of blood cells and by solving the quadratic equation, we can know the numbers of hit cells by alpha particles and all other measurements.

Before the beginning of this semester, I prepared some chemical samples in Jordan. These samples are used for medical purposes and include Methylthymol blue-synthetic polymer gel dosimeter with glutaraldehyde cross-linker. Where they were irradiated using a linear accelerator (LINAC) for studying the effect of different dose response, dose rate and energy on these samples also to know the stability and sensitivity for these samples. Then were analyzed and studied using spectrophotometer, nuclear magnetic resonance (NMR) and CCD camera.

Publications

1- Molham Eyadeh, Khalid Rabaeh, Feras M. O. Al-dweri, Mohammad Al-Shorman,Samer Alheet, Samer Awad, **Tariq F. Hailat**. Nuclear magnetic resonance analysis of chemically cross-linked ferrous-methylthymol blue-polyvinyl alcohol radiochromic gel dosimeter. *Applied Radiation and Isotopes.***(Submitted)**

Educational activities in current semester

I registered four courses in this semester. These courses are Computer Modelling in Biology course (6 Credits), Monte Carlo method course (6 Credits), Quantitative models of mechanisms in developmental biology course (6 Credits)and Ionizing radiation in the human environment, their biological and potential health effects course (6 Credits). Also, I registered for the Guided Research Work (18 Credits). The total of the Credits in this semester is 42 Credits.

1- Computer Modelling in Biology course

This course provides a "hands-on" introduction into mathematical/computational modelling of biological processes with particular emphasis on problems drawn from evolutionary and population biology. By cooperation with the lecturer (Dr. Viktor Müller) and working in small teams, we developed some modelling exercises with different levels of difficulty from a list of projects. They complete the whole life cycle of a modelling (mini-) project: from the identification of a biological problem, through its "translation" to mathematical / computational model, to the evaluation, interpretation and presentation of the results. We learned about some interesting problems of evolutionary and population biology, acquired practical skills in the modelling of biological problems, and experience team work. The models were done by the open-source software (R) by modifying and adding to existing example programs.

2- **Monte Carlo method course**

This course is based on the simulation work for some chemical aspects, as it is good for knowing and understanding the simulation models using the Monte Carlo methods.

The lecturer (Dr. Pál Jedlovszky) taught us the basics of computer simulations such as deriving macroscopic properties from microscopic information, then finding the probability of realization of the various possible microscopic states in a given macroscopic state. Also, we have learned some of Monte Carlo simulations on various ensembles (canonical (N,V,T) ensemble, isothermal-isobaric (N,p,T) ensemble, grand canonical (μ,V,T) ensemble and simulation of phase equilibrium without any interface – Gibbs ensemble). In addition to these subjects, the course includes other topics such as choosing the interaction sites, displacement of the molecules in the simulation, relative position of the interaction sites, intermolecular interactions, Combination of the pair interaction parameters between sites of different types and defining the cut-off distance of the pair potential.

3- **Quantitative models of mechanisms in developmental biology course**

The course covered some of mechanisms – and the corresponding mathematical or computational models – underlying various cell- and developmental biological phenomena. Dr. András Czirók sent for us more than 12 papers where they were read, understand, discussed and analyzed during this semester. Some of these papers were

- The Influence of Cell Mechanics, Cell-Cell Interactions, and Proliferation on Epithelial Packing
- Vertex Models of Epithelial Morphogenesis
- Nature and anisotropy of cortical forces orienting Drosophila tissue morphogenesis
- Glassy dynamics in three-dimensional embryonic tissue
- Modeling Gastrulation in the Chick Embryo: Formation of the Primitive Streak
- Generation of Robust Left-Right Asymmetry in the Mouse Embryo Requires a Self-Enhancement and Lateral-Inhibition System.

4- **Ionizing radiation in the human environment, their biological and potential health effects course**

In this course, Dr. István Turai taught us many important subjects such as radioactive decay laws, artificial radioactive isotopes and activity and dose and the measurement of radiation. In addition to these chapters, the course included many of chapters like the natural radiation sources and doses to the people, nuclear weapons – reactor accidents, radiation used for therapy – radiation therapy, radiation damage to biomolecules and radiation and health – Cancer.

Grants and awards:

1- I got a grant to attend **"XV Seminar on Software for Nuclear, Subnuclear and Applied Physics"** in Hotel Porto Conte, Alghero, Italy, in the period from May 26 to May 31, 2019. This grant included the registration fee of the seminar.

2- I have applied to get a grant from t**he ESA-FAIR Space Radiation School to attend this summer school** in Darmstadt, Germany from September 15 to October 1, 2019.

Conferences in current semester

1- I attended **the XVI Seminar on Software for Nuclear, Sub nuclear and Applied Physics** in Hotel Porto Conte, Alghero, Italy, in the period from May 26 to May 31, 2019. This seminar was very useful and interesting as it contained and included the following full subjects: introduction to Python, Introduction to Machine Learning, introduction to Geant4 and Monte Carlo methods and practical exercises about geant4 and practical Sessions on Kernel.

2- I contributed in **Two Oral Presentations** at the Seventh International Conference on Radiation in Various Fields of Research (RAD 2019) about radiation measurements at the Hunguest Hotel Sun Resort, Herceg Novi, Montenegro in the period from June10 to June 14, 2019.

- The first abstract entitled: "Computational cell dosimetry for alpha-particle exposure by Monte-Carlo methods". **Tariq F. Hailat**, Emese Drozsdik, Balázs G. Madas.
- The second abstract entitled: "Dosimetric characterization Methylthymol blue Fricke gel dosimeters using nuclear magnetic resonance and optical techniques". **Tariq F. Hailat**, Molham M. Eyadeh, Khalid A. Rabaeh, Balázs G. Madas, Feras M. Aldweri.