Internship Proposal 2026

Tracking of irradiated cells, Image Analysis, and Modeling

The team Modélisation des Systèmes Vivants at the IJCLab laboratory in Orsay works on modeling questions related to clinical and biological data, but also to statistical physics. Our research focuses on gliomas, or brain tumors. These tumors are invasive, meaning that the cancer cells migrate, sometimes over long distances, making recurrence after treatment (e.g., radiotherapy) almost inevitable.

New spatially structured irradiation methodologies are currently being developed, allowing for the sparing of healthy tissues while maintaining good efficacy against the tumor: cells are irradiated with spatially periodic doses, high in the peaks and low in the valleys. The model generally used to estimate the fraction of surviving cells after irradiation is the linear-quadratic model, which does not take into account the effect of high doses (although this is the case in peaks), nor that of cell interactions (which modulate the effect of irradiation via the bystander effect, in particular), nor that of tumor cell migration, which causes the mixing of normal/tumor cells, irradiated/non-irradiated cells.

We recently proposed a new compartmental model of cell population evolution after irradiation, which allows us to identify the different cell populations present (damaged, repaired, senescent cells, etc.) and which has shown that the fraction of surviving cells after irradiation in 2D depends on the initial cell density, a factor not taken into account by the linear-quadratic model [1]. To better understand what happens during irradiation, we now wish to study the tracking of individual cells, and this is the focus of this internship proposal.

This project combines experiments, image analysis, and modeling:

- Experimental part: cell culture, using a videomicroscope to track individual cells for four days. The cells will be irradiated with different doses (by permanent staff).

- Image analysis will generate quantitative data on trajectories, the number of mitoses, survival, migration speed, cell-cell contacts, etc.

- Finally, based on the data, a discrete stochastic agent-centered model will be developed to test scenarios, explain, and reproduce the obtained data. If possible, the continuous limit of this discrete model will be calculated and compared to the existing continuous model [1].

This internship may lead to a PhD. In this case, other systems will be studied and modeled: evolution of cell populations (co-cultures of tumor/healthy cells with uniform or structured irradiation, addition of nanoparticles enhancing the effect of irradiation, new cell lines) in 2D, evolution of spheroids (3D) after irradiation…The candidate must hold a Master's degree in physics. She/he should have an aptitude for biophysics experiments, as well as mathematical modeling, numerical simulations, biological data processing, and image analysis. An interest in issues related to cancer will also be appreciated.

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[1] M Billoir, D Crepin, S Plaszczynski, B Grammaticos, O Seksek, M Badoual (2025) *The temporal response of a glioma cell population to irradiation: modelling the effect of dose and cell density*, Royal Society Open Science 12 (4), 241917