Effects of ion fragmentation and dose rate on water and biomolecule radiolysis

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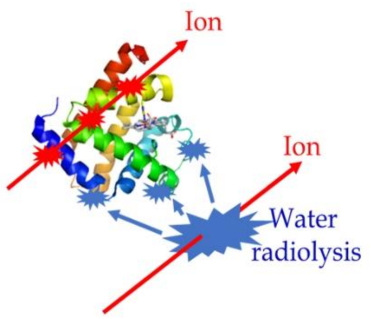
Context

Radiotherapy offers many advantages in the fight against cancer, and is widely used alongside chemotherapy and surgery. In most treatment centers, the ionizing radiations used are X-rays of a few mega-electronvolts, but other modalities are also used. Radiotherapy using accelerated ions, or hadrontherapy, is a rapidly expanding method worldwide. Accelerated ions offer a number of advantages over the more commonly used X-rays, such as greater biological efficacy and more localized dose deposition in the tumor.

However, heavy ions such as carbon ions and, to a lesser extent, helium ions, are prone to fragmentation by nuclear interactions. The fragments formed being much lighter, they will deposit dose behind the targeted volume, with a possible risk for healthy tissues.



Schematic representation of the effects of accelerated ions as they pass near or through a molecule.

On the other hand, FLASH radiotherapy has been attracting a great deal of interest in the scientific and medical communities in recent years. This is an ultra-high dose-rate therapy, i.e. one in which the energy of the ionizing radiation, or dose, is deposited very rapidly in the body. Very high dose rates (>100 Gy/s; 1 Gy =1 J/kg) have been shown to reduce damage to healthy tissue compared with conventional therapy (~0.1 Gy/s), while the impact on the tumor remains unchanged.

PhD project

In this project, the candidate will study the physics of fragmentation of high-energy ions used for therapy, and the impact of fragments on water radiolysis. They will also study the effects of dose-rate on water radiolysis species, with various amounts of O_2 dissolved in solution.

Studies with ions will be conducted also on biomolecules; peptides and lipids; in similar conditions as for water radiolysis.

Irradiation experiments will be conducted on IPHC cyclotron Cyrcé, at Himac, in Japan, and at CNAO, Italy.

DeSIs and Radiochimie team researches focus on the physics and chemistry of accelerated ions-matter interaction. Both teams are collaborating on these subjects through doctoral theses and projects (ANR CLINM 24-28). The PhD will be conducted in close collaboration between DeSIs and Radiochimie teams of IPHC, and with National Institutes for Quantum Science and Technology (QST) and Kobe University, Japan.

The candidate should have a strong interest for pluridisciplinary studies, between physics, chemistry and biochemistry.