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# Laser-plasma accelerators and femtosecond photon sources based ultrafast radiation chemistry and biomedicine

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It is generally admitted that an initial spatial distribution of energy deposition following the interaction of ionising radiations (UV and X rays, electron, proton and accelerated ions) with living matter (molecular targets or integrated biological systems) is decisive for the behaviour and control of radiation effects that take place on several orders of magnitude. The complex links that exist between the chemical physics of radiations and biomedical applications such as imaging and anticancer treatment (radio and chemo-radiotherapies) require the understanding of early events triggered by an initial energy deposition in confined sub-micrometric ionisation spaces (tracks).
Recent advances of powerful TW laser sources (~10E19 W cm-2) and laser-plasma interactions providing ultra-short relativistic particle beams in the energy domain 5-200 MeV open exciting opportunities for the development of high energy radiation femtochemistry (HERF). Early radiation damages being dependent on the survival probability of secondary electrons and radial distribution of short-lived radicals inside ionization clusters, a thorough knowledge of these processes involves the real-time probing of primary events in the temporal range 10E-14 - 10E-11 s. In the framework of a closed synergy between low energy radiation femtochemistry (LERF) and the emerging domain of HERF, the lecture will focus on early phenomena that occur in the prethermal regime of low energy secondary electrons, considering very short-lived quantum effects in aqueous environments. A high dose rate delivered by femtosecond electron beam (~10E11-10E13 Gy s-1) can be used to investigate early radiation processes in native ionisation tracks, down to 10E-12 s and 10E-9 m. We will explain how this breakthrough favours the innovating development of real-time nanodosimetry in biologically relevant environments and open new perspectives for spatio-temporal radiation biomedicine. New developments would permit to correlate early radiation events triggered by ultrashort radiation sources with a molecular approach of Relative Biological Efficiency (RBE). The modulated response of biological endpoints, healthy cell survivals or carcinogenesis processes represents a real challenge to get the optimized control of ultra-high dose-rate effects, before the characterisation of clinical protocols devoted to pulsed radio-chemotherapy of cancers.

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