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Filamentation of femtosecond laser pulses in solutions of biological interest: low-density plasma as a new pattern of ionizing radiation for radiobiology and radiotherapy

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Recently, the utilization of the interaction of femtosecond laser pulses with system of biological interest arose from new original studies in radiobiology. Indeed, through the generation of low-density plasmas, femtosecond laser pulses can be thought as a singular source of numerous ionizations. Within this framework, we intend to take advantage of the filamentation of powerful lasers pulses as a way to generate self-regulated spatially homogeneous low-density plasma spots along the laser-beam propagation axis within biological material. The deleterious effects of laser pulses (800nm, 35fs, 5mJ) propagating through aqueous solutions (chemical dosimeter, DNA) have been compared with the genotoxic effects produced by a more conventional source of ionizing radiations (gamma-rays from 137Cs). Furthermore, we investigated the anti-tumorous impact of a laser-plasma interaction on breast tumour MC7-L1 implanted subcutaneously in Balb/c mice. This sequence of experiments allowed us to conclude that the occurrence of laser filamentation in biomolecular bench mark systems, such as thymidine and DNA plasmid solutions, yields highly spatially localized and malleable energy deposit and clear genotoxic results. In vivo, after an optimization stage of the laser-plasma interaction, the laser irradiation resulted in a complete tumour regression. In conclusion, femtosecond laser filamentation can provide a micro-beam of ionizing radiation, paving the way for new applications of photonic processes in radiobiology and cancer radiotherapy. However, contrary to the photo-disruptive optical breakdown interaction in a tissue for biomedical application, low-density plasmas lack a relevant non-perturbative model to improve our understanding of the physics, chemistry and biology underlying its effects in biological environnements.

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