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On the relative role of the physical mechanisms on complex biodamage induced by carbon irradiation

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The effective use of swift ion beams in cancer treatment (known as hadrontherapy) as well as an appropriate protection in manned space missions rely on the accurate understanding of energy delivery to cells damaging their genetic information [1]. The key ingredient characterizing the response of a medium to the perturbation induced by charged particles is its electronic excitation spectrum. By using linear response time-dependent density functional theory, we obtain the energy and momentum transfer excitation spectrum (the energy-loss function, ELF) of liquid water which is the main constituent of biological tissue, in excellent agreement with experimental data [2,3]. The inelastic scattering cross sections obtained from this ELF, together with the elastic scattering cross sections derived considering the condensed phase nature of the medium, are used to perform accurate Monte Carlo simulations of the energy deposited by swift carbon ions in liquid water and carried away by the generated secondary electrons producing inelastic events (ionization, excitation, and dissociative electron attachment), strongly correlated with cellular death, which are scored in sensitive volumes having the size of two DNA convolutions [2,3,4]. The sizes of clusters of damaging events for a wide range of carbon ion energies, from those relevant to hadrontherapy up to cosmic radiation, predict with unprecedented statistical accuracy the nature and relative magnitude of the main inelastic processes contributing to radiation biodamage, confirming that ionization accounts for the vast majority of complex damage, while DEA only adds up for a minor contribution. Applications to the calculation of the ELF and REEL spectra in ceria [5] and of beta-decay will be shown in this talk [6,7]

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