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Simple yet reasonably accurate simulations of dose point kernels in liquid water by iodine radionuclides

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Nowadays, many advances in medicine come hand in hand with new developments in physics. Nuclear medicine is responsible for trying to diagnose and cure diseases using radioactive isotopes, unstable atomic nuclei that emit energy due to various processes, such as β^- decays or discrete Auger electron emissions. These ejected electrons carry the excess energy of the excited nucleus and deliver energy to matter as they travel through it interacting with its atoms and molecules, so that in the end a given spatial distribution of dose is produced around the emission point. Depending on the type of process that triggers the electron release, determined by the nature of each radioisotope, the energy emitted and its distribution around the emission point may change. If we know how the energy spreads in the medium, depending on each isotope, we can choose which one will be more convenient to use in a particular clinical situation.

For example, some techniques such as radio-immunotherapy introduce different radioactive isotopes bound to antibodies selectively into the nuclei of cancer cells to cause their death due to the emission of low energy electrons, which may confine the dose within the nuclei of the ill cells. The problem here is that it is not trivial to accurately know how the dose is distributed, especially at the small nanometer scales of the sensitive biomolecules such as DNA.

In this work we have developed a Monte Carlo simulation code that follows in detail the motion through liquid water of the electrons emitted by radioactive iodine nuclides (either ^{131}I or ^{125}I, which emit through different deexcitation mechanisms). The elastic collisions of the electrons are taken into account by a screened Rutherford cross section [1,2], whereas the inelastic collisions, leading to the energy loss of the electrons, is accounted for by empirical approximate stopping power formulas for high and low energy electrons [1,3]. The extension of such approach to take into account the ejection of secondary electrons is explored, trying to keep the simplicity and speed of the simulation code by appropriate parametrisation of more detailed energy-loss models [4].

Despite the simplicity of the simulation code, the obtained dose point kernels for electrons emitted by radioactive iodine isotopes show promising agreement with available experimental data [5], as well as other simulations [6] and theoretical calculations [7].

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