HEAVY ION IRRADIATION INFLUENCE ON THE THERMODYNAMIC PROPERTIES OF SALINE SOLUTION

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Because of the great success of proton therapy new approaches are presently studied in order to further increase the efficiency of radiotherapy. One of the ways for significant improvement: is to use heavy ions to improve the dose distribution and to produce an increased biological efficiency in the tumor only. Heavy-ion therapy is the use of particles more massive than protons or neutrons, such as carbon, neon, argon ions. Compared to protons, ions have an advantage: due to the higher density of ionisation at the end of their range, correlated damages of the DNA structure within one cell occur more often so that it becomes more difficult for the cancerous cell to repair the damage. Compared to protons, ions have the disadvantage that beyond the Bragg peak, the dose does not decrease to zero, since nuclear reactions between the ions and the atoms of the tissue lead to production of lighter ions which have a higher range. Therefore, some damage occurs also beyond the Bragg peak. In order to minimize the possibility of such a situation it is important to understand the changes made to the thermodynamic properties of the intercellular liquids by the irradiation. Therefore, in this work we try to develop the theory describing the changes of the thermodynamic properties of liquids under the irradiation and the results are compared with the model intercellular liquid that was set to be the NaCl solution (saline solution).

Based on the fundamental chain of Bogoliubov equations the method to calculate the "effective" temperature of the system in the case of its irradiation by the charged particles of constant intensity is suggested. Introducing such "effective" temperature allows for describing thermodynamic properties of biological liquids in the nonequilibrium stationary state employing the formalism of the equilibrium thermodynamics. In that case their structural properties are defined by the "effective" temperature that is characteristic to the equilibrium system with the thermodynamic properties similar to those observed in the nonequilibrium system. Existence of that temperature different from the real measured temperature is explained by the deviation of the momentum distribution function from the equilibrium Maxwell distribution. To confirm the theoretical predictions the molecular dynamics simulations in the DL_POLY package were done to study the local structure of the NaCl solutions under the irradiation. Analysis of the results shows that under the irradiation the local structures are formed both with destroying the hydrogen bonds and without it. Therefore, it is shown that the structure of the solution is being changed that within the suggested theory indicates the presence of the "effective" temperature characterizing thermodynamic properties of the system.