CARCINOGENESIS EVOLUTION BASED ON CONDITIONS OF THE MULTI-PARAMETRIC SPACE AND INITIAL STATES OF A BIOLOGICAL SYSTEM

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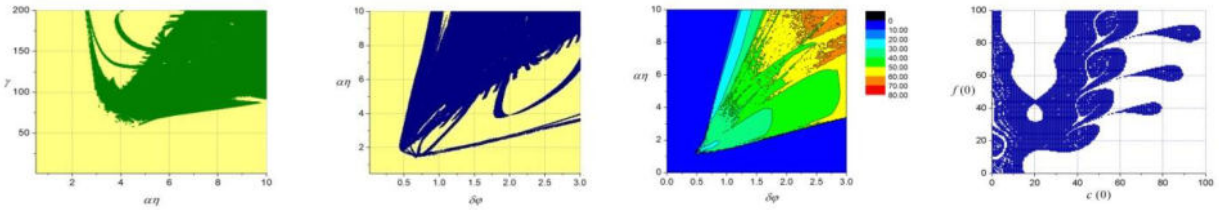
In this study it was demonstrated a significant and complex mutual influence of all components of the multi-parametric space: 'number of tumor cells – tumor cell volume – glucose level – diffusion saturation level' as well as the 3D initial state space components on inhibition/amplification of carcinogenesis in biological systems. A non-linear multi-scale diffusion cancer invasion model that describes the interactions of the tumor cells, matrix-metalloproteinases (MM), matrix-degradative enzymes (MDE) and oxygen was employed for simulations. To quantify chaotic cancer attractors, the technique based on the wandering trajectories analysis was applied. Conditions resulting in cancer invasion were defined depending on parameters of the multi-parametric space.

Time histories and phase spaces of the regular oscillations near one of the chemical equilibrium, chaotic attractors in the concentration phase spaces have been presented. Amplitude level contours of MM, MDE and oxygen concentrations have been obtained and juxtaposed with the corresponding parametric planes. In all cases the carcinogenesis is accompanied by significant increase in chemical oscillation amplitudes of the concentrations. The results obtained allow a multi-parametric evaluation of the modes to inhibit and stabilize carcinogenesis. For more background, we refer to [1, 2] and references therein. These results can help in optimizing the treatment planning process and in designing new ones as well as for improving predictability of the outcomes.



(a) (b) (c) (d)

Figure 1 – Conditions leading to cancer invasion in a biological system: (a) control parameter planes ($\alpha\eta$, γ) – 'number of tumor cells vs tumor cell volume'; (b) ($\delta\varphi$, $\alpha\eta$) – 'tumor cell volume vs diffusion saturation level'; (c) amplitude level contours of MM concentration in ($\delta\varphi$, $\alpha\eta$) control parameter plane; (f) biological system initial states leading to chaotic cancer attractors

References:

1. Dzyubak L., Dzyubak O., Awrejcewicz J. Controlling and stabilizing unpredictable behaviour of metabolic reactions and carcinogenesis in biological systems. *J. Nonlinear Dynamics* **97**, 1853–1866, 2019.

2. Dzyubak L., Dzyubak O., Awrejcewicz J. Nonlinear multiscale diffusion cancer invasion model with memory of states, *Chaos, Solitons & Fractals* **168**, 113091, 2023.