

Title: *Billiard time machine*

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Abstract: *In this work we investigate a simple interacting system of an elastic particle in the non-relativistic spacetime with a nontrivial causal structure realized by a wormhole with a time shift. We require that standard local physical laws hold, and search for their globally consistent solutions, i.e., we assume the validity of the principle of self-consistency. If there were nontrivial set of initial conditions which would violate this principle, the system would be logically inconsistent. We show that the investigated system is not inconsistent in this sense, i.e., that all standard initial conditions have a globally consistent evolution. Even for the so called dangerous initial conditions which threaten to result into the paradoxical situation a consistent solution exists. In this case, the paradoxical collision-free trajectory is superseded by a special consistent self-colliding trajectory. Moreover, we demonstrate that more than one globally consistent evolution exists for a wide class of initial conditions. Thus, the evolution of the described system is not unique due to the nontrivial causal structure of the spacetime. We find and analyze all solutions with multiple self-collisions for the point-particle, and all trajectories with one self-collision for the finite ball. Thanks to the chosen model we are able carry out a detailed explicit analysis of the structure of solutions. This elaborated model can be reused for another analysis, for example, study of systems with multiple self-collisions of the finite ball, which can be necessary for resolution of open problems.*

Keywords: *wormhole time machines, principle of self-consistency, conical space, evolution of the system, self-collision, self-intersection, dangerous initial conditions, paradoxical self-intersection, dangerous self-collision*