The impact of non-smoothness in the tyre-force characteristics on the nonlinear dynamics of towed wheels

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In this study, we investigate the lateral and yaw dynamics of towed road vehicles by means of an in-plane, single track model with an elastic tyre. It is shown how the dry friction in the tyre-ground contact can lead to piecewise-smooth continuous governing equations and how this feature of the system influences the periodic orbits. The bifurcation of the rectilinear motion is thoroughly investigated using numerical collocation with the aim to point out the qualitative differences with respect smooth dynamical systems. Namely, the branches of periodic orbits emerge in a conical structure from the linear stability boundary instead of a paraboloid one that is characteristic to Hopf bifurcations in smooth systems. A further goal of the analysis is to discover the so-called bistable parameter ranges which correspond to subcritical bifurcations. In these domains, the system can converge either to the rectilinear motion or a stable limit cycle depending on the initial conditions. Additionally, a semi-analytical calculation is performed which can help to explore the structure of the nonlinear system in detail.