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Dynamic analysis of a unique Jerk system with a smoothly adjustable symmetry and nonlinearity: Reversals of period doubling, Offset boosting and Coexisting bifurcations

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Abstract: We investigated the dynamics of a novel jerk system generalized with a single parametric nonlinearity in the form $\varphi_k(x) = 0.5(\exp(kx) - \exp(-x))$. The form of nonlinearity is interesting in the sense that the corresponding circuit realization involves only off-the shelf electronic components such as resistors, semiconductor diodes and operational amplifiers. Parameter k (i.e. a control resistor) serves to smoothly adjust the shape of the nonlinearity, and hence the symmetry of the system. In particular, for $k = 1$, the nonlinearity is a hyperbolic sine, and thus the system is point symmetric about the origin. For $k \neq 1$, the system is non-symmetric. To the best of the authors' knowledge, this interesting feature is unique and has not yet been discussed in chaotic systems. The dynamic analysis of the model involves a preliminary study of basic properties such as the nature of the fixed point, the transitions to chaos (bifurcation diagrams), the phase portraits as well as the Lyapunov exponent diagrams. When monitoring the system parameters, some striking phenomena are found including period doubling cascade bifurcation, reverse bifurcations, merging crises, offset boosting, coexisting bifurcations and hysteresis. Several windows in the parameters' space are depicted in which the novel jerk system displays a plethora of coexisting asymmetric and symmetric attractors (i.e. coexistence of two, three or four different attractors) depending only on the selection of initial states. The magnetization of state space due to the presence of multiple competing solutions is illustrated by means of basins of attraction. More importantly, multistability in the symmetry boundary is discussed by