Jounce Newtonian equations for oscillating memristive circuits

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The prediction made by L. O. Chua 40+ years ago (see: IEEE Trans. Circuit Theory, 18 (1971) 507-519 and also: Proc. IEEE, 100 (2012) 1920-1927) about the existence of a passive element (called memristor) that links the charge and flux variables has been confirmed by the HP lab group in its report (see: Nature, 453 (2008) 80-83) on a successful construction of such an element. This sparked an enormous interest in mem-elements, analysis of their unusual dynamical properties (i.e. pinched hysteresis loops, memory effects, etc.) and construction of their emulators.
In this talk we discuss certain properties of the memristive circuits yielding mixed-mode oscillations. Mathematical models of such circuits can be linked to the Newton's law $\phi'' - F(t, \phi, \phi')/m = 0$, with ϕ denoting the flux or charge variables, m is a positive constant and the nonlinear function F contains memory terms. This leads further to scalar fourth-order ODEs called the *jounce* Newtonian equations. The *jounce* equations are used to construct the *RC*+ op-amp simulation circuits in SPICE. Also, the linear *RC* and *RL* circuits with sinusoidal inputs are derived to match the *RMS* values of the memristive periodic circuits. SPICE and Matlab are used in the illustrative examples of periodic responses and calculations of their *RMS* and one-period energy values.