# A Tau method for nonlinear dynamical systems

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Originally, the Tau method proposed by Lanczos was developed to approximate the solution of a linear ordinary differential equation. The operational version of the method, as in other methods of weighted residuals, or in other spectral methods, is based on solving a system of linear algebraic equations, obtained by imposing certain conditions for the minimization of the residual.

The generalization of the Tau method for solving nonlinear differential equations usually involves some kind of linearization of the problem and the subsequent use of the method's version for linear problems. In this work we propose an alternative technique by associating a nonlinear algebraic system to the nonlinear differential problem. We show that this system can be rearranged in order to allow resolution using forward substitution, and so avoiding the linearization of the given problem.

We present the application of an adaptive step by step version of this alternative nonlinear Tau method to several nonlinear dynamical systems problems, including to the Lorenz equations where we verify that the method is sufficiently stable to recover the known attractor.