MODELING CHAOTIC BEHAVIOR OF NONLINEAR DYNAMO EQUATIONS USING AN ARTIFICIAL NEURAL NETWORK

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Nonlinear dynamo models are crucial in understanding the generation of magnetic fields in astrophysical plasmas. This work looks into the complicated behavior of a nonlinear dynamo system consisting of four connected differential equations that have nonlinear coefficients [1]. The system models the mutual interaction of two subsystems through state-dependent parameters. As shown in [1], numerical integration reveals signatures of chaotic behavior. Phase portraits and temporal dynamics illustrate the sensitivity to initial conditions and the emergence of irregular attractors. We investigated the potential for using artificial neural networks (ANNs) to model nonlinear dynamo equations [1] and predict chaotic behavior of large-scale vortex (x, p) and magnetic fields (X, P). The system was numerically integrated using the fourth-order Runge-Kutta method over the time interval $t \in [0, 2000]$. The resulting data set was used to train a feedforward neural network to approximate the state transitions. After training, the ANN was used in an autoregressive mode to simulate the system's evolution. Fig. 1 shows the results of computer simulations.

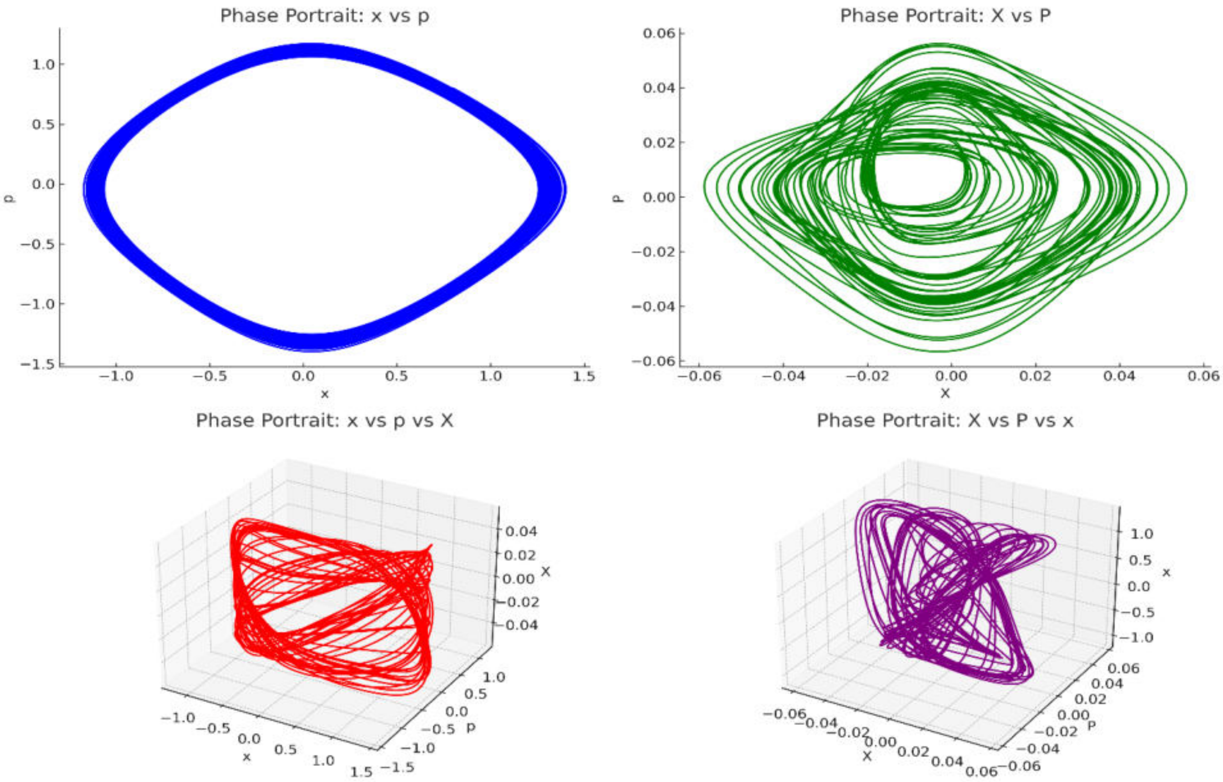

Fig. 1. – These portraits reveal irregular loops, divergence in state space, and complex behavior typical of chaotic systems. There is an obvious excellent fit with the phase portraits from work [1]

References:

1. Kopp M. I., Tur A. V., Yanovsky V. V. Nonlinear Dynamo. arXiv:1612.08860v1. 2016.