

## CHAOTIC BEHAVIOR IN THE FAMILY OF LORENZ SYSTEM

AKRAM ASHYANI, HAJIMOHAMMAD MOHAMMADINEJAD AND OMID RABIEIMOTLAGH

ABSTRACT. In this paper we consider a system of Lorenz family which is more general than the unified system containing Lorenz, Chen and Lü systems. We apply the center manifold method and show that the system can pass through pitchfork and Hopf bifurcations which in turn take the system into a chaotic behavior.

### REFERENCES

- [1] Q.H. Alsafasfeh and M.S. Al-Arni: *A new chaotic behavior from Lorenz and Rossler systems and its electronic circuit implementation*, Circuits Syst., **2**(2011), 101-105.
- [2] R. Barrio and S. Serrano: *A three-parametric study of the Lorenz model*, Phys. D, **229**(2007), 43-51.
- [3] R. Barrio and S. Serrano: *Bounds for the chaotic region in the Lorenz model*, Phys. D, **238**(2009), 1615-1624.
- [4] S. Čelikovský and A. Vaněček: *Systems and chaos*, Kybernetika, **30**(1994), 403-424.
- [5] Y. Chang and G. Chen: *Complex dynamics in Chen's system*, Chaos Solitons Fractals, **27**(2006), 75-86.
- [6] G. Chen and T. Ueta: *Yet another chaotic attractor*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **9**(1999), 1465-1466.
- [7] J. Chen, J. Lu and X. Wu: *Bidirectionally coupled synchronization of the generalized Lorenz systems*, J. Syst. Sci. Complex., **24**(2011), 43-448.
- [8] J.K. Hale: *Ordinary Differential Equation*, 2nd edition, Krieger Publishing Company Malabar, Florida, New York, 1980.
- [9] Y. Liu and W. Pang: *Dynamics of the general Lorenz family*, Nonlinear Dyn., **67**(2012), 1595-1611.
- [10] E.N. Lorenz: *Deterministic nonperiodic flow*, J. Atmos. Sci., **20**(1963), 131-141.
- [11] J. Lü and G. Chen: *A new chaotic attractor coined*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **12**(2002), 61-65.
- [12] J. Lü, G. Chen, D. Cheng and S. Čelikovský: *Bridge the gap between the Lorenz system and the Chen system*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **12**(2002), 2917-2926.
- [13] T. Miyano, K. Cho, Y. Okada, J. Tatsutani and T. Toriyama: *Augmented Lorenz equations as physical model for chaotic gas turbine*, Procedia IUTAM, **5**(2012), 99-107.
- [14] J. Palacián and P. Yanguas: *Periodic orbits of the Lorenz system through perturbation theory*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **10**(2001), 2559-2566.
- [15] C. Sparrow: *The Lorenz Equations: Bifurcation, Chaos and Strange Attractor*, Springer, New York, 1982.
- [16] A. Vaněček and S. Čelikovský: *Control Systems: from Linear Analysis to Synthesis of Chaos*, Prentice Hall, London, 1996.
- [17] Q. Wang, J. Li and W. Huang: *Existence of multiple limit cycles in Chen system*, J. Appl. Anal. Comput., **2**(2012), 441-447.
- [18] S. Wiggins: *Introduction to Applied Nonlinear Dynamical Systems and Chaos*, Berlin, Springer, 1990.
- [19] P. Yu and X. Liao: *Globally attractive and positive invariant set of the Lorenz system*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **3**(2006), 757-764.

---

Received: February 10, 2014. Revised: May 31, 2015.

2010 Mathematics Subject Classification: 34A34.

Key words and phrases: Lorenz unified system, center manifold, Pitchfork bifurcation, Hopf bifurcation.

- [20] T. Zhou, Y. Tang and G. Chen: *Complex dynamical behaviors of the chaotic chen's system*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **13**(2003), 2561-2574.

*University of Birjand*  
*Faculty of Science*  
*Department of Mathematics*  
*Birjand, Iran*  
*E-mail address: a.ashyani@birjand.ac.ir*

*University of Birjand*  
*Faculty of Science*  
*Department of Mathematics*  
*Birjand, Iran*  
*E-mail address: hmohammadin@birjand.ac.ir*

*University of Birjand*  
*Faculty of Science*  
*Department of Mathematics*  
*Birjand, Iran*  
*E-mail address: orabieimotlagh@birjand.ac.ir*