Explosive death in direct and indirectly coupled oscillators: Review

Aashima Sharma

21msp1040@cuchd.in

Dr. Amit Sharma

Amit.e11102@cumail.in

**Abstract**. The transition in the dynamical behavior in the coupled system has several applications in science. The phase transitions of synchronization and oscillation suppression have both been thoroughly researched for a very long time. The second-order transition, which is continuous and reversible, is demonstrated by the standard results in the vast majority of cases in the coupled system. Recently, the first-order transition reported in oscillation suppression have been reported in the complex network of the coupled oscillators through direct and indirect interaction. Explosive death is a transition that is not only abrupt but also irreversible in its parameters. We currently have a very good grasp of first order transition in oscillation death in networked systems and a variety of significant contributions and advancements have substantially improved it. Here, we aim to provide a review on the explosive death in various direct and indirect coupled oscillator scenarios while reviewing the previous findings.

References: [1] Fujisaka, H. and Yamada, T., 1983. Stability theory of synchronized motion in coupled-oscillator systems. *Progress of theoretical physics*, *69*(1), pp.32-47.

[2] Heagy, J.F., Carroll, T.L. and Pecora, L.M., 1994. Synchronous chaos in coupled oscillator systems. *Physical Review E*, *50*(3), p.1874.

[3] Pikovsky, A. and Rosenblum, M., 2007. Synchronization. *Scholarpedia,*2(12), p.1459.

[4] Achlioptas, D., D'Souza, R.M. and Spencer, J., 2009. Explosive percolation in random networks. science, 323(5920), pp.1453-1455.

[5] Pikovsky, A. and Rosenblum, M., 2007. Synchronization. Scholarpedia, 2(12), p.1459.

[6] Gómez-Gardenes, J., Gómez, S., Arenas, A. and Moreno, Y., 2011. Explosive synchronization transitions in scale-free networks. *Physical review letters*, *106*(12), p.128701.

[7] Zhang, X., Hu, X., Kurths, J. and Liu, Z., 2013. Explosive synchronization in a general complex network. *Physical Review E*, *88*(1), p.010802.

[8] Boccaletti, S., Almendral, J.A., Guan, S., Leyva, I., Liu, Z., Sendiña-Nadal, I., Wang, Z. and Zou, Y., 2016. Explosive transitions in complex networks’ structure and dynamics: Percolation and synchronization. *Physics Reports*, *660*, pp.1-94.

[9] Bar-Eli, K., 1985. On the stability of coupled chemical oscillators. *Physica D: Nonlinear Phenomena*, *14*(2), pp.242-252.

[10] Saxena, G., Prasad, A. and Ramaswamy, R., 2012. Amplitude death: The emergence of stationarity in coupled nonlinear systems. *Physics Reports*, *521*(5), pp.205-228.

[11] Koseska, A., Volkov, E. and Kurths, J., 2013. Transition from amplitude to oscillation death via Turing bifurcation. *Physical review letters*, *111*(2), p.024103.

[12] Koseska, A., Volkov, E. and Kurths, J., 2013. Oscillation quenching mechanisms: Amplitude vs. oscillation death.*Physics Reports*, 531(4), pp.173-199.

[13] Mirollo, R.E. and Strogatz, S.H., 1990. Amplitude death in an array of limit-cycle oscillators. Journal of Statistical Physics, 60(1), pp.245-262.

[14] Prasad, A., 2005. Amplitude death in coupled chaotic oscillators. *Physical Review E*, *72*(5), p.056204.

[15] Song, G., Buck, N.V. and Agrawal, B.N., 1999. Spacecraft vibration reduction using pulse-width pulse-frequency modulated input shaper. *Journal of guidance, control, and dynamics*, *22*(3), pp.433-440.

[16] Prasad, A., Lai, Y.C., Gavrielides, A. and Kovanis, V., 2003. Amplitude modulation in a pair of time-delay coupled external-cavity semiconductor lasers. *Physics Letters A*, 318(1-2), pp.71-77.

[17] Koseska, A., Ullner, E., Volkov, E., Kurths, J. and García-Ojalvo, J., 2010. Cooperative differentiation through clustering in multicellular populations. *Journal of theoretical biology*, *263*(2), pp.189-202.

[18] Suzuki, N., Furusawa, C. and Kaneko, K., 2011. Oscillatory protein expression dynamics endows stem cells with robust differentiation potential. *PloS one*, *6*(11), p.e 27232.

[19] Bi, H., Hu, X., Zhang, X., Zou, Y., Liu, Z. and Guan, S., 2014. Explosive oscillation death in coupled Stuart-Landau oscillators. *EPL (Europhysics Letters)*, *108*(5), p.50003.

[20] Verma, U.K., Sharma, A., Kamal, N.K., Kurths, J. and Shrimali, M.D., 2017. Explosive death induced by mean–field diffusion in identical oscillators. *Scientific reports*, *7*(1), pp.1-7.

[21] Verma, U.K., Sharma, A., Kamal, N.K. and Shrimali, M.D., 2018. First order transition to oscillation death through an environment. *Physics Letters A*, *382*(32), pp.2122-2126.

[22] Zhao, N., Sun, Z., Yang, X. and Xu, W., 2018. Explosive death of conjugate coupled van der Pol oscillators on networks. *Physical Review E*, *97*(6), p.062203.

[23] Verma, U.K., Sharma, A., Kamal, N.K. and Shrimali, M.D., 2019. Explosive death in complex network. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, *29*(6), p.063127.

[24] Verma, U.K., Sharma, A., Kamal, N.K. and Shrimali, M.D., 2019. Explosive death in complex network. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, *29*(6), p.063127.

[25] Sun, Z., Liu, S. and Zhao, N., 2021. Explosive and semi-explosive death in coupled oscillators. *Chaos, Solitons & Fractals*, *142*, p.110514.

[26] Dixit, S., Chowdhury, S.N., Ghosh, D. and Shrimali, M.D., 2021. Dynamic interaction induced explosive death. *Europhysics Letters*, *133*(4), p.40003.

[27] Liu, S., Sun, Z., Zhao, N. and Xu, W., 2021. Explosive death induced by environmental coupling. *Communications in Nonlinear Science and Numerical Simulation*, *98*, p.105774.

[28] Katriel, G., 2008. Synchronization of oscillators coupled through an environment. *Physica D: Nonlinear Phenomena*, *237*(22), pp.2933-2944.

[29] Resmi, V., Ambika, G. and Amritkar, R.E., 2010. Synchronized states in chaotic systems coupled indirectly through a dynamic environment. *Physical Review E*, *81*(4), p.046216.

[30] Sharma, A., Dev Shrimali, M. and Kumar Dana, S., 2012. Phase-flip transition in nonlinear oscillators coupled by dynamic environment. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, *22*(2), p.023147.

[31] McMillen, D., Kopell, N., Hasty, J. and Collins, J.J., 2002. Synchronizing genetic relaxation oscillators by intercell signaling. *Proceedings of the National Academy of Sciences*, *99*(2), pp.679-684.

[32] Ullner, E., Zaikin, A., Volkov, E.I. and García-Ojalvo, J., 2007. Multistability and clustering in a population of synthetic genetic oscillators via phase-repulsive cell-to-cell communication. *Physical review letters*, *99*(14), p.148103.

[33] Ullner, E., Koseska, A., Kurths, J., Volkov, E., Kantz, H. and García-Ojalvo, J., 2008. Multistability of synthetic genetic networks with repressive cell-to-cell communication. *Physical Review E*, *78*(3), p.031904.

[34] Bennett, M., Schatz, M.F., Rockwood, H. and Wiesenfeld, K., 2002. Huygens's clocks. *Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences*, *458*(2019), pp.563-579.

[35] Taylor, A.F., Tinsley, M.R., Wang, F., Huang, Z. and Showalter, K., 2009. Dynamical quorum sensing and synchronization in large populations of chemical oscillators. *science*, *323*(5914), pp.614-617.

[36] Gonze, D., Bernard, S., Waltermann, C., Kramer, A. and Herzel, H., 2005. Spontaneous synchronization of coupled circadian oscillators. *Biophysical journal*, *89*(1), pp.120-129.

[37] Javaloyes, J., Perrin, M. and Politi, A., 2008. Collective atomic recoil laser as a synchronization transition. *Physical Review E*, *78*(1), p.011108.

[38] Tang, C.L., Statz, H. and deMars, G., 1963. Spectral output and spiking behavior of solid‐state lasers. *Journal of Applied Physics*, *34*(8), pp.2289-2295.

[39] Sharma, A. and Shrimali, M.D., 2011. Synchronization of indirectly coupled Lorenz oscillators: An experimental study. *Pramana*, *77*(5), pp.881-889.