

# References

1. Ahmad, S., Rao, M.R.M.: Asymptotically periodic solutions of  $N$ -competing species problem with time delays. *J. Math. Anal. Appl.* **186**, 559–571 (1994)
2. Ahmad, S., Stamov, G.Tr.: Almost periodic solutions of  $N$ -dimensional impulsive competitive systems. *Nonlinear Anal. Real World Appl.* **10**, 1846–1853 (2009)
3. Ahmad, S., Stamov, G.Tr.: On almost periodic processes in impulsive competitive systems with delay and impulsive perturbations. *Nonlinear Anal. Real World Appl.* **10**, 2857–2863 (2009)
4. Ahmad, S., Stamova, I.M.: Asymptotic stability of an  $N$ -dimensional impulsive competitive system. *Nonlinear Anal. Real World Appl.* **8**, 654–663 (2007)
5. Ahmad, S., Stamova, I.M.: Global exponential stability for impulsive cellular neural networks with time-varying delays. *Nonlinear Anal.* **69**, 786–795 (2008)
6. Akca, H., Alassar, R., Covachev, V., Covacheva, Z., Al-Zahrani, E.: Continuous-time additive Hopfield-type neural networks with impulses. *J. Math. Anal. Appl.* **290**, 436–451 (2004)
7. Akhmet, M.U., Beklioglu, M., Ergenc, T., Tkachenko, V.I.: An impulsive ratio-dependent predator–prey system with diffusion. *Nonlinear Anal. Real World Appl.* **7**, 1255–1267 (2006)
8. Akhmetov, M.U.: Recurrent and almost-periodic solutions of nonautonomous systems with impulse. *Izv. Akad. Nauk Kaz. SSR.* **3**, 8–10 (1988)
9. Akhmetov, M.U., Perestyuk, N.A.: Almost periodic solutions of nonlinear impulse systems. *Ukrainian Math. J.* **41**, 291–296 (1989)
10. Alzabut, J.O., Nieto, J.J., Stamov, G.Tr.: Existence and exponential stability of positive almost periodic solutions for a model of hematopoiesis. *Bound. Value Probl.* 2009, 1–10 (2009)
11. Alzabut, J.O., Stamov, G.Tr., Sermutlu, E.: On almost periodic solutions for an impulsive delay logarithmic population model. *Math. Comput. Model.* **51**, 625–631 (2010)
12. Amerio, L.: Soluzioni quasi-periodiche, o limitate, di sistemi differenziali non lineari quasi-periodici, o limitati. *Ann. Mat. Pura. Appl.* **39**, 97–119 (1955)
13. Andronov, A.A., Vitt, A.A., Haykin, S.E.: *Oscillation Theory*. Nauka, Moscow (1981); (in Russian)
14. Bachar, M., Arino, O.: Stability of a general linear delay-differential equation with impulses. *Dyn. Contin. Discrete Impuls. Syst. Ser. A Math. Anal.* **10**, 973–990 (2003)
15. Bainov, D.D., Simeonov, P.S.: *Impulsive Differential Equations: Periodic Solutions and Applications*. Longman, Harlow (1993)

16. Bainov, D.D., Kostadinov, S.I., Myshkis, A.D.: Bounded periodic solutions of differential equations with impulsive effect in a Banach space. *Differ. Integr. Equat.* **1**, 223–230 (1988)
17. Bainov, D.D., Myshkis, A.D., Stamov, G.T.: Dichotomies and almost periodicity of the solutions of systems of impulsive differential equations. *Dynam. Syst. Appl.* **5**, 145–152 (1996)
18. Bainov D.D., Dishliev, A.B., Stamov, G.T.: Almost periodic solutions of hyperbolic systems of impulsive differential equations. *Kumamoto J. Math.* **10**, 1–10 (1997)
19. Bellman, R., Cooke, K.L.: *Differential-Difference Equations*. Academic Press, New York (1963)
20. Benchohra, M., Henderson, J., Ntouyas, S.: *Impulsive Differential Equations and Inclusions*. Hindawi, New York (2006)
21. Besicovitch, A.S.: *Almost Periodic Functions*. Dover, New York (1954)
22. Bochner, S.: Beitrage zur theorie der fastperiodischen funktionen, I: funktionen einer variablen. *Math. Ann.* **96**, 119–147 (1927); (in German)
23. Bochner, S.: Homogeneous systems of differential equations with almost periodic coefficients. *J. London Math. Soc.* **8**, 283–288 (1933)
24. Bochner, S., von Neumann, J.: Almost periodic functions of groups. II. *Trans. Amer. Math. Soc.* **37**, 21–50 (1935)
25. Bogolyubov, N.N., Mitropolskii, Y.A.: *Asimptotic Methods in the Theory of Nonlinear Variations*. Nauka, Moscow (1974); (in Russian)
26. Bohr, H.: Zur theorie der fastperiodischen funktionen. II: Zusammenhang der fast-periodischen funktionen mit funktionen von unendlich vielen variablen; gleichmssige approximation durch trigonometrische summen. *Acta Math.* **46**, 101–214 (1925); (in German)
27. Bohr, H., Neugebauer, O.: Uber lineare differentialgleichungen mit konstanten koefizienten und fastperiodischer rechter seite. *Nachr. Ges. Wiss. Geottingen. Math.-Phys. Klasse.* 8–22 (1926); (in German)
28. Burton, T.A., Zhang, B.: Uniform ultimate boundedness and periodicity in functional differential equations. *Tohoku Math. J.* **42**, 93–100 (1990)
29. Butler, G., Freedman, H.I., Waltman, P.: Uniformly persistent systems. *Proc. Amer. Math. Soc.* **96**, 425–430 (1986)
30. Cao, J.: On stability of delayed cellular neural networks. *Phys. Lett. A* **261**, 303–308 (1999)
31. Cao, J.: Global exponential stability of Hopfield neural networks. *Internat. J. Syst. Sci.* **32**, 233–236 (2001)
32. Cao, J., Wang, J.: Global exponential stability and periodicity of recurrent neural networks with times delays. *IEEE Trans. Cir. Syst. I Regul. Pap.* **52**, 920–931 (2005)
33. Cao, J., Chen, A., Huang, X.: Almost periodic attractor of delayed neural networks with variable coefficients. *Phys. Lett. A* **340**, 104–120 (2005)
34. Chen, A., Cao, J.: Existence and attractivity of almost periodic solutions for cellular neural networks with distributed delays and variable coefficients. *Appl. Math. Comput.* **134**, 125–140 (2003)
35. Chen, G.: Control and stabilization for the wave equation in a bounded domain. I. *SIAM J. Contr. Optim.* **17**, 66–81 (1979)
36. Chen, G., Shen, J.: Boundedness and periodicity for impulsive functional differential equations with applications to impulsive delayed Hopfield neuron networks. *Dyn. Contin. Discrete Impuls. Syst. Ser. A Math. Anal.* **14**, 177–188 (2007)
37. Chen, M.P., Yu, J.S., Shen, J.H.: The persistence of nonoscillatory solutions of delay differential equations under impulsive perturbations. *Comput. Math. Appl.* **27**, 1–6 (1994)
38. Chen, T.: Global exponential stability of delayed Hopfield neural networks. *Neural Netw.* **14**, 977–980 (2001)
39. Chetayev, N.G.: *The Stability of Motion*. Pergamon Press, Oxford (1961)

40. Chua, L.O.: CNN: A Paradigm for Complexity. World Scientific, Singapore (1998)
41. Chua, L.O., Roska, T.: Stability of a class of nonreciprocal cellular neural networks. *IEEE Trans. Circ. Syst. I* **37**, 1520–1527 (1990)
42. Chua, L.O., Yang, L.: Cellular neural networks: theory. *IEEE Trans. Circ. Syst.* **35**, 1257–1272 (1988)
43. Chua, L.O., Yang, L.: Cellular neural networks: applications: *IEEE Trans. Circ. Syst.* **35**, 1273–1290 (1988)
44. Civalleri, P.P., Gilli, M.: A set of stability criteria for delayed cellular neural networks. *IEEE Trans. Circ. Syst. I* **48**, 494–498 (2001)
45. Coddington, E.A., Levinson, N.: *Theory of Ordinary Differential Equations*. McGraw-Hill, New York (1955)
46. Coppel, W.: Dichotomies and reducibility. *J. Differ. Equat.* **3**, 500–521 (1967)
47. Corduneanu, C.: *Almost Periodic Functions*. Interscience Publication, New York (1968)
48. Cui, W.: Global stability of a class of neural networks model under dynamical thresholds with delay. *J. Biomath.* **15**, 420–424 (2000)
49. Dafermos, C.M.: Almost periodic processes and almost periodic solutions of evolution equations. In: *Dynamical Systems (Proceedings of International Symposium, University of Florida, Gainesville, Florida, 1976)*, pp. 43–57. Academic Press, New York (1977)
50. Dalec'kii, Ju.L., Krein, M.G.: *Stability of Solutions of Differential Equations in Banach Space*. American Mathematical Society, Providence (1974)
51. Dannan, F., Elaydi, S.: Lipschitz stability of nonlinear systems of differential equations. *J. Math. Anal. Appl.*, **113**, 562–577 (1986)
52. Demidovich, B.P.: *Lectures on the Mathematical Theory of Stability*. Nauka, Moscow (1967); (In Russian)
53. Driver, R.: *Ordinary and Delay Differential Equations*. Springer, New York (1977)
54. Fan, M., Wang, K., Jiang, D.: Existence and global attractivity of positive periodic solutions of periodic species Lotka–Volterra competition systems with several deviating arguments. *Math. Biosci.* **160**, 47–61 (1999)
55. Fink, A.M.: *Almost Periodic Differential Equations*. Lecture Notes in Mathematics. **377**, Springer, Berlin (1974)
56. Fink, A.M.: Almost periodic solutions to forced Lienard equations. In: *Nonlinear Vibration Problems*, No. 15 (Proceedings of Sixth International Conference on Nonlinear Oscillations, Pozna, 1972, Part II), pp. 95–105. PWN-Polish Sci. Publ., Warsaw (1974)
57. Fink, A.M., Seifert, G.: Lyapunov functions and almost periodic solutions for almost periodic systems. *J. Differ. Equat.* **5**, 307–313 (1969)
58. Friedman, A.: *Partial Differential Equations*. Holt, Rinehart and Winston, New York (1969)
59. Gopalsamy, K.: *Stability and Oscillation in Delay Differential Equations of Population Dynamics*. Kluwer, Dodrecht (1992)
60. Gopalsamy, K., Leung, I.K.C.: Convergence under dynamical thresholds with delays. *IEEE Trans. Neural Netw.* **8**, 341–348 (1997)
61. Gopalsamy, K., Zhang, B.: On delay differential equations with impulses. *J. Math. Anal. Appl.* **139**, 110–122 (1989)
62. Gurgulla, S.I., Perestyuk, N.A.: On Lyapunov's second method in systems with impulse action. *Dokl. Akad. Nauk Ukrain. SSR Ser. A* **10**, 11–14 (1982); (in Russian)
63. Halanay, A., Wexler, D.: *Qualitative Theory of Impulse Systems*. Mir, Moscow (1971); (in Russian)
64. Hale, J.K.: *Theory of Functional Differential Equations*. Springer, New York (1977)
65. Hartman, P.: *Ordinary Differential Equations*. Wiley, New York (1964)

66. He, M., Chen, F., Li, Z.: Almost periodic solution of an impulsive differential equation model of plankton allelopathy. *Nonlinear Anal. Real World Appl.* **11**, 2296–2301 (2010)
67. Hekimova, M.A., Bainov, D.D.: Almost periodic solutions of singularly perturbed systems of differential equations with impulse effect. *Forum Math.* **1**, 323–329 (1989)
68. Henry, D.: *Geometric Theory of Semilinear Parabolic Equations*. Springer, Berlin (1981)
69. Hino, Y.: Stability and existence of almost periodic solutions of some functional differential equations. *Tohoku Math. J.* **28**, 389–409 (1976)
70. Hopfield, J.J.: Neurons with graded response have collective computational properties like those of two-stage neurons. *Proc. Natl. Acad. Sci. USA* **81**, 3088–3092 (1984)
71. Hristova, S.G., Bainov, D.D.: Integral surfaces for hyperbolic ordinary differential equations with impulses effect. *COMPEL* **4**, 1–18 (1995)
72. Hu, D., Zhao, H., Zhu, H.: Global dynamics of Hopfield neural networks involving variable delays. *Comput. Math. Applicat.* **42**, 39–45 (2001)
73. Huang, H., Cao, J.: On global asymptotic stability of recurrent neural networks with time-varying delays. *Appl. Math. Comput.* **142**, 143–154 (2003)
74. Huang, X., Cao, J.: Almost periodic solutions of shunting inhibitory cellular neural networks with time-varying delays. *Phys. Lett. A* **314**, 222–231 (2003)
75. Jiang, G., Lu, Q.: Impulsive state feedback control of a predator–prey model. *J. Comput. Appl. Math.* **200**, 193–207 (2007)
76. Jin, Z., Maoan, H., Guihua, L.: The persistence in a Lotka–Volterra competition systems with impulsive perturbations. *Chaos Solut. Fractals* **24**, 1105–1117 (2005)
77. Jost, C., Ariono, O., Arditi, R.: About deterministic extinction in ratio-dependent predator–prey models. *Bull. Math. Biol.* **61**, 19–32 (1999)
78. Kapur, J.N.: *Mathematical Modelling*. Wiley, New York (1988)
79. Khadra, A., Liu, X., Shen, X.: Application of impulsive synchronization to communication security. *IEEE Trans. Circ. Syst. I Fund. Theor. Appl.* **50**, 341–351 (2003)
80. Khadra, A., Liu, X., Shen, X.: Robust impulsive synchronization and application to communication security. *Dyn. Contin. Discrete Impuls. Syst.* **10**, 403–416 (2003)
81. Kim, S., Campbell, S., Liu, X.: Stability of a class of linear switching systems with time delay. *IEEE Trans. Circ. Syst. I* **53**, 384–393 (2006)
82. Kirlinger, G.: Permanence in Lotka–Volterra equations: Linked prey–predator systems. *Math. Biosci.* **82**, 165–191 (1986)
83. Kolmanovskii, V.B., Nosov, V.R.: *Stability of Functional-Differential Equations*. Academic Press, London (1986)
84. Krasnosel'skii, M.A., Burd, V.Sh., Kolesov, Yu.S.: *Nonlinear Almost Periodic Oscillations*. Wiley, New York (1973)
85. Krasovskii, N.N.: *Certain Problems in the Theory of Stability of Motion*. Fiz.-Mat. Lit., Moscow (1959); (in Russian)
86. Krasovskii, N.N.: *Stability of Motion*. Stanford University Press, Stanford (1963)
87. Krishna, S., Vasundhara, J., Satyavani, K.: Boundedness and Dichotomies for Impulsive Equations. *J. Math. Anal. Appl.* **158**, 352–375 (1991)
88. Kuang, Y.: *Delay Differential Equations with Applications in Population Dynamics*. Academic Press, Boston (1993)
89. Kulenovic, M.R.S., Ladas, G.: *Linearized oscillations in population dynamics*. *Bull. Math. Biol.* **49**, 615–627 (1987)
90. Kulev, G.K., Bainov, D.D.: Strong stability of impulsive systems. *Internat. J. Theoret. Phys.* **27**, 745–755 (1988)
91. Lakshmikantham, V., Leela, S.: *Differential and Integral Inequalities: Theory and Applications*. Academic Press, New York (1969)
92. Lakshmikantham, V., Liu, X.: *Stability Analysis in Terms of Two Measures*. World Scientific, River Edge (1993)

93. Lakshmikantham, V., Rao, M.R.M.: *Theory of Integro-Differential Equations*. Gordon and Breach, Lausanne (1995)
94. Lakshmikantham, V., Bainov, D.D., Simeonov, P.S.: *Theory of Impulsive Differential Equations*. World Scientific, Teaneck (1989)
95. Lakshmikantham, V., Leela, S., Martynyuk, A.A.: *Stability Analysis of Nonlinear Systems*. Marcel Dekker, New York (1989)
96. Lakshmikantham, V., Leela, S., Martynyuk, A.A.: *Practical Stability Analysis of Nonlinear Systems*. World Scientific, Singapore (1990)
97. Levitan, B.M.: *Almost Periodic Functions*. Gostekhizdat, Moscow (1953); (in Russian)
98. Levitan, B.M., Zhikov, V.V.: *Almost Periodic Functions and Differential Equations*. Cambridge University Press, Cambridge (1983)
99. Li, M., Duan, Y., Zhang, W., Wang, M.: The existence of positive periodic solutions of a class of Lotka–Volterra type impulsive systems with infinitely distributed delay. *Comput. Math. Appl.* **49**, 1037–1044 (2005)
100. Liao, X., Ouyang, Z., Zhou, S.: Permanence of species in nonautonomous discrete Lotka–Volterra competitive system with delays and feedback controls. *J. Comput. Appl. Math.* **211**, 1–10 (2008)
101. Lisena, B.: Extinction in three species competitive systems with periodic coefficients. *Dynam. Syst. Appl.* **14**, 393–406 (2005)
102. Liu, J.: Bounded and periodic solutions of finite delay evolution equations. *Nonlinear Anal.* **34**, 101–111 (1998)
103. Liu, X.: Stability results for impulsive differential systems with applications to population growth models. *Dynam. Stabil. Syst.* **9**, 163–174 (1994)
104. Liu, X.: Stability of impulsive control systems with time delay. *Math. Comput. Model.* **39**, 511–519 (2004)
105. Liu, X., Ballinger, G.: Existence and continuability of solutions for differential equations with delays and state-dependent impulses. *Nonlinear Anal.* **51**, 633–647 (2002)
106. Liu, Y., Ge, W.: Global attractivity in delay "food-limited" models with exponential impulses. *J. Math. Anal. Appl.* **287**, 200–216 (2003)
107. Liu, Z.J.: Positive periodic solutions for delay multispecies Logarithmic population model. *J. Engrg. Math.*, **19**, 11–16 (2002); (in Chinese).
108. Liu, B., Liu, X., Liao X.: Robust stability of uncertain dynamical systems. *J. Math. Anal. Appl.* **290**, 519–533 (2004)
109. Lotka, A.: *Elements of Physical Biology*. Williams and Wilkins, Baltimore (1925); [Reprinted as: *Elements of Mathematical Biology*. Dover, New York (1956)]
110. Luo, Z., Shen, J.: Stability and boundedness for impulsive functional differential equations with infinite delays. *Nonlinear Anal.* **46**, 475–493 (2001)
111. Lyapunov, A.M.: *General Problem on Stability of Motion*. Grostechizdat, Moscow (1950); (in Russian)
112. Mackey, M.C., Glass, L.: Oscillation and chaos in physiological control system. *Science* **197**, 287–289 (1977)
113. Malkin, I.G.: *Theory of Stability of Motion*. Nauka, Moscow (1966); (in Russian)
114. Markoff, A.: Stabilität im Liapounoffschen Sinne und Fastperiodizität. *Math. Z.* **36**, 708–738 (1933); (in German)
115. Martin, R.H.: *Nonlinear Operators and Differential Equations in Banach Spaces*. Wiley, New York (1976)
116. Massera, J.L.: Contributions to stability theory. *Ann. of Math.* **64**, 182–206 (1956)
117. Maynard-Smith, J.: *Models in Ecology*. Cambridge University Press, Cambridge (1974)
118. McRae, F.: Practical stability of impulsive control systems. *J. Math. Anal. Appl.* **181**, 656–672 (1994)
119. Mil'man, V.D., Myshkis, A.D.: On the stability of motion in the presence of impulses. *Siberian Math. J.* **1**, 233–237 (1960); (in Russian)

120. Mohamad, S.: Global exponential stability of continuous-time and discrete-time delayed bidirectional neural networks. *Phys. Nonlinear Phenom.* **159**, 233–251 (2001)
121. Mohamad, S., Gopalsamy, K.: A unified treatment for stability preservation in computer simulation of impulsive BAM networks. *Comput. Math. Appl.* **55**, 2043–2063 (2008)
122. Neugebauer, O.: *The Exact Sciences in Antiquity*. Braun University Press, Providence (1957)
123. Nicholson, A.J.: The balance of animal population. *J. Anim. Ecol.* **2**, 132–178 (1933)
124. Nieto, J.: Periodic boundary value problems for first-order impulsive ordinary differential equations. *Nonlinear Anal.* **51**, 1223–1232 (2002)
125. Nindjin, A.F., Aziz-Alaoui, M.A., Cadivel, M.: Analysis of predator–prey model with modified Leslie-Gower and Holling-type II schemes with time delay. *Nonlinear Anal. Real World Appl.* **7**, 1104–1118 (2006)
126. Pazy, A.: *Semigroups of Linear Operators and Applications to Partial Differential Equations*. Springer, New York (1983)
127. Perestyuk, N.A., Ahmetov, M.U.: On almost periodic solutions of a class of systems with periodic impulsive action. *Ukrainian Math. J.* **36**, 486–490 (1984)
128. Perestyuk, N.A., Chernikova, O.S.: On the stability of integral sets of impulsive differential systems. *Math. Notes (Miskolc)* **2**, 49–60 (2001)
129. Randelovic, B.M., Stefanovic, L.V., Dankovic, B.M.: Numerical solution of impulsive differential equations. *Facta Univ. Ser. Math. Inform.* **15**, 101–111 (2000)
130. Rao M.R.M., Rao, V.S.H.: Stability of impulsively perturbed systems. *Bull. Austral. Math. Soc.* **16**, 99–110 (1977)
131. Rao, M.R.M., Sathanantham, S. and Sivasundaram, S.: Asymptotic behavior of solutions of impulsive integro-differential systems. *Appl. Math. Comput.* **34**, 195–211 (1989)
132. Razumikhin, B.S.: *Stability of Hereditary Systems*. Nauka, Moscow (1988); (in Russian)
133. Roska, T., Wu, C.W., Balsi, M., Chua, L.O.: Stability and dynamics of delay-type general cellular neural networks. *IEEE Trans. Circuits Syst. I* **39**, 487–490 (1992)
134. Rouche, H., Habets, P., Laloy, M.: *Stability Theory by Lyapunov's Direct Method*. Springer, New York (1977)
135. Saaty, T.L., Joyce, M.: *Thinking with Models: Mathematical Models in the Physical, Biological, and Social Sciences*. Pergamon Press, Oxford (1981)
136. Samoilenko, A.M., Perestyuk, N.A.: Stability of the solutions of differential equations with impulse effect. *Diff. Eqns.* **11**, 1981–1992 (1977); (in Russian)
137. Samoilenko, A.M., Perestyuk, N.A.: Periodic and almost periodic solutions of differential equations with impulses. *Ukrainian Math. J.* **34**, 66–73 (1982)
138. Samoilenko, A.M., Perestyuk, N.A.: *Differential Equations with Impulse Effect*. World Scientific, Singapore (1995)
139. Samoilenko, A.M., Trofimchuk, S.: Spaces of piecewise-continuous almost-periodic functions and of almost-periodic sets on the line I. *Ukrainian Math. J.* **43**, 1613–1619 (1991); (in Russian)
140. Samoilenko, A.M., Trofimchuk, S.: Spaces of piecewise-continuous almost-periodic functions and of almost-periodic sets on the line II. *Ukrainian Math. J.*, **44**, 389–400 (1992); (in Russian)
141. Samoilenko, A.M., Perestyuk, N.A., Akhmetov, M. U.: *Almost Periodic Solutions of Differential Equations with Impulse Action*. Akad. Nauk Ukrain. SSR Inst. Mat., Kiev (1983); (in Russian)
142. Seifert, G.: A condition for almost periodicity with some applications to functional differential equations. *J. Differ. Equat.* **1**, 393–408 (1965)
143. Seifert, G.: Almost periodic solutions for almost periodic systems of ordinary differential equations. *J. Differ. Equat.* **2**, 305–319 (1966)

144. Seifert, G.: Nonlinear evolution equation with almost periodic time dependence. *SIAM J. Math. Anal.* **18**, 387–392 (1987)
145. Shen, J.: Razumikhin techniques in impulsive functional differential equations. *Nonlinear Anal.* **36**, 119–130 (1999)
146. Shen, J., Li, J.: Impulsive control for stability of Volterra functional differential equations. *Z. Anal. Anwendungen* **24**, 721–734 (2005)
147. Siljak, D.D., Ikeda, M., Ohta, Y.: Parametric stability. In: *Proceedings of the Universita di Genova-Ohio State University Joint Conference*, pp. 1–20. Birkhauser, Boston (1991)
148. Simeonov, P.S., Bainov, D.D.: Estimates for the Cauchy matrix of perturbed linear impulsive equation. *Internat. J. Math. Math. Sci.* **17**, 753–758 (1994)
149. Stamov, G.T.: Almost periodic solutions for systems of impulsive integro-differential equations. *Appl. Anal.* **64**, 319–327 (1997)
150. Stamov, G.T.: Almost periodic solutions and perturbations of the linear part of singularly impulsive differential equations. *Panamer. Math. J.* **9**, 91–101 (1999)
151. Stamov, G.T.: Semi-separated conditions for almost periodic solutions of impulsive differential equations. *J. Tech. Univ. Plovdiv Fundam. Sci. Appl. Ser. A Pure Appl. Math.* **7**, 89–98 (1999)
152. Stamov, G.T.: Almost periodic solutions for forced perturbed impulsive differential equations. *Appl. Anal.* **74**, 45–56 (2000)
153. Stamov, G.T.: On the existence of almost periodic Lyapunov functions for impulsive differential equations. *Z. Anal. Anwendungen* **19**, 561–573 (2000)
154. Stamov, G.T.: Separated conditions for almost periodic solutions of impulsive differential equations with variable impulsive perturbations. *Comm. Appl. Nonlinear Anal.* **7**, 73–82 (2000)
155. Stamov, G.T.: Existence of almost periodic solutions for strong stable impulsive differential equations. *IMA J. Math. Contr. Inform.* **18**, 153–160 (2001)
156. Stamov, G.T.: Separated and almost periodic solutions for impulsive differential equations. *Note Mat.* **20**, 105–113 (2001)
157. Stamov, G.T.: Asymptotic stability of almost periodic systems of impulsive differential-difference equations. *Asymptot. Anal.* **27**, 1–8 (2001)
158. Stamov, G.Tr.: Existence of almost periodic solutions for impulsive differential equations with perturbations of the linear part. *Nonlinear Stud.* **9**, 263–273 (2002)
159. Stamov, G.Tr.: Second method of Lyapunov for existence of almost periodic solutions for impulsive integro-differential equations. *Kyungpook Math. J.* **43**, 221–231 (2003)
160. Stamov, G.T.: Families of Lyapunov's functions for existence of almost periodic solutions of  $(h_0, h)$ -stable impulsive differential equations. *Nonlinear Stud.* **10**, 135–150 (2003)
161. Stamov, G.Tr.: Lyapunov's functions for existence of almost periodic solutions of impulsive differential equations. *Adv. Stud. Contemp. Math. (Kyungshang)* **8** (2004), 35–46 (2004)
162. Stamov, G.Tr.: Impulsive cellular neural networks and almost periodicity. *Proc. Japan Acad. Ser. A Math. Sci.* **80**, 198–203 (2004)
163. Stamov, G.Tr.: Asymptotic stability in the large of the solutions of almost periodic impulsive differential equations. *Note Mat.* **24**, 75–83 (2005)
164. Stamov, G.Tr.: Almost periodic solutions of impulsive differential equations with time-varying delay on the PC-space. *Nonlinear Stud.* **14**, 269–279 (2007)
165. Stamov, G.Tr.: Almost periodic impulsive equations in a Banach space. *J. Tech. Uni. Sliven* **2**, 3–11 (2007)
166. Stamov, G.T.: Almost periodic models in impulsive ecological systems with variable diffusion. *J. Appl. Math. Comput.* **27**, 243–255 (2008)
167. Stamov, G.Tr.: Existence of almost periodic solutions for impulsive cellular neural networks. *Rocky Mt. J. Math.* **38**, 1271–1285 (2008)



168. Stamov, G.Tr.: On the existence of almost periodic solutions for impulsive Lasota-Ważewska model. *Appl. Math. Lett.* **22**, 516–520 (2009)
169. Stamov, G.Tr.: Almost periodic models of impulsive Hopfield neural networks. *J. Math. Kyoto Univ.* **49**, 57–67 (2009)
170. Stamov, G.Tr.: Almost periodic processes in ecological systems with impulsive perturbations. *Kyungpook Math. J.* **49**, 299–312 (2009)
171. Stamov, G.Tr.: Almost periodic solutions in impulsive competitive systems with infinite delays. *Publ. Math. Debrecen* **76**, 89–100 (2010)
172. Stamov, G.Tr.: Almost periodicity and Lyapunov's functions for impulsive functional differential equations with infinite delays. *Canad. Math. Bull.* **53**, 367–377 (2010)
173. Stamov, G.Tr., Alzabut, J.O.: Almost periodic solutions for abstract impulsive differential equations. *Nonlinear Anal.* **72**, 2457–2464 (2010)
174. Stamov, G.Tr., Petrov, N.: Lyapunov-Razumikhin method for existence of almost periodic solutions of impulsive differential-difference equations. *Nonlinear Stud.* **15**, 151–161 (2008)
175. Stamov, G.Tr., Stamova, I.M.: Almost periodic solutions for impulsive neural networks with delay. *Appl. Math. Model.* **31**, 1263–1270 (2007)
176. Stamova, I.M.: Global asymptotic stability of impulse delayed cellular neural networks with dynamical threshold. *Nonlinear Stud.* **13**, 113–122 (2006)
177. Stamova, I.M.: *Stability Analysis of Impulsive Functional Differential Equations*. Walter de Gruyter, Berlin (2009)
178. Stamova, I.M., Stamov, G.T.: Lyapunov-Razumikhin method for impulsive functional differential equations and applications to the population dynamics. *J. Comput. Appl. Math.* **130**, 163–171 (2001)
179. Sternberg, S.: *Celestial Mechanics. Part I*. W. A. Benjamin, New York (1969)
180. Taam, C.T.: *Asymptotically Periodic and Almost Periodic Polutions of Nonlinear Differential Equations in Banach Spaces*. Technical Reports, Georgetown University, Washington (1966)
181. Takeuchi, Y.: *Global Dynamical Properties of Lotka–Volterra Systems*. World Scientific, Singapore (1996)
182. Tineo, A.: Necessary and sufficient conditions for extinction of one species. *Adv. Nonlinear Stud.* **5**, 57–71 (2005)
183. Veech, W.A.: Almost automorphic functions on groups. *Amer. J. Math.* **87**, 719–751 (1965)
184. Volterra, V.: Fluctuations in the abundance of a species considered mathematically. *Nature* **118**, 558–560 (1926)
185. Wang, L., Chen, L., Nieto, J.J.: The dynamics of an epidemic model for pest control with impulsive effect. *Nonlinear Anal. Real World Appl.* **11**, 1374–1386 (2010)
186. Ważewska-Czyżewska, M., Lasota, A.: Mathematical problems of the dynamics of a system of red blood cells. *Mat. Stos.* **6**, 23–40 (1976)
187. Wei, F., Wang, K.: Asymptotically periodic solution of  $n$ -species cooperation system with time delay. *Nonlinear Anal. Real World Appl.* **7**, 591–596 (2006)
188. Xia, Y.: Positive periodic solutions for a neutral impulsive delayed Lotka–Volterra competition system with the effect of toxic substance. *Nonlinear Anal. Real World Appl.* **8**, 204–221 (2007)
189. Xinzhu, M.: Almost periodic solution for a class of Lotka–Volterra type  $N$ -species evological systems with time delay. *J. Syst. Sci. Complex.* **18**, 488–497 (2005)
190. Xu, W., Li, J.: Global attractivity of the model for the survival of red blood cells with several delays. *Ann. Differ. Equat.* **14**, 357–363 (1998)
191. Xue, Y., Wang, J., Jin, Z.: The persistent threshold of single population under pulse input of environmental toxin. *WSEAS Trans. Math.* **6**, 22–29 (2007)
192. Ye, D., Fan, M.: Periodicity in impulsive predator–prey system with Holling III functional response. *Kodai Math. J.*, **27**, 189–200 (2004)



193. Yoshizawa, T.: Stability Theory by Lyapunov's Second Method. The Mathematical Society of Japan, Japan (1966)
194. Yoshizawa, T.: Asymptotically almost periodic solutions of an almost periodic system. Funkcial. Ekvac. **12**, 23–40 (1969)
195. Yoshizawa, T.: Some remarks on the existence and the stability of almost periodic solutions. SIAM Studies in Apl. Math. **5**, 166–172 (1969)
196. Zanolin, F.: Permanence and positive periodic solutions for Kolmogorov competing species systems. Results Math. **21**, 224–250 (1992)
197. Zhang, B.: Boundedness in functional differential equations. Nonlinear Anal. **22**, 1511–1527 (1994)
198. Zhang, B.G., Gopalsamy, K.: Global attractivity in the delay logistic equation with variable parameters. Math. Proc. Cambridge Philos. Soc. **170**, 579–590 (1990)
199. Zhang, Y., Sun, J.: Stability of impulsive delay differential equations with impulses at variable times. Dyn. Syst. **20** (2005), 323–331 (2005)
200. Zhao, C., Wang, K.: Positive periodic solutions of a delay model in population. Appl. Math. Lett. **16**, 561–565 (2003)
201. Zhikov, V.V.: The problem of almost periodicity for differential and operator equations. Matematika **8**, 94–188 (1969)
202. Zhong, W., Lin, W., Jiong, R.: The stability in neural networks with delay and dynamical threshold effects. Ann. Differ. Equat. **17**, 93–101 (2001)

# Index

## A

$\varepsilon$ -Almost period, 16, 25, 84  
Almost periodic  
    function(s), xix, 25, 72, 84  
        in the sense of Bohr, xx, 24  
        matrix-valued, 35  
        piecewise continuous, 1, 30  
        projector-valued, 71, 75  
    sequence(s), 1, 16  
Almost periodicity, vii, 1, 71  
Applications, 151  
Asymptotically stable, 15, 16, 85  
Attractive, 15, 16

## B

Banach space, 17, 82  
Beating, 4  
Bihari inequality, 13  
Biological models, 151  
Bounded, 17, 26

## C

Cauchy matrix, 9, 49, 53, 71, 159, 164  
Cellular neural networks (CNN), xvi  
Column dominant, 48  
Comparison equation, 12, 108  
Continuability, 1, 5, 7, 8  
    to the left, 8  
    to the right, 7  
Continuable, 7, 8  
Control, xvi, xviii

## D

Dichotomies, 71  
Diffusion, 94

Dini derivative, 10, 11, 32  
Distance, 72

## E

Epicycles, xviii  
Equi-attractive, 15, 16  
Equi-bounded, 99, 100  
 $\varepsilon$ -Equivalent, 72  
Existence, 1, 5, 33, 97  
Exponential dichotomy, 71  
Exponentially stable, 16, 37, 44, 46, 50, 155, 161, 194

## F

Function  
    continuous, 2  
    left continuous, 2  
    Lipschitz continuous, 4, 5, 7  
    locally integrable, 6  
    normal, xx  
    piecewise continuous, 2, 4  
    regular, xix  
Fundamental matrices, 35

## G

Generating system, 48  
Globally asymptotically stable, 99, 168  
Globally exponentially stable, 168, 172  
Globally perfectly uniform-asymptotically stable, 99, 116  
Globally quasi-equi-asymptotically stable, 99  
Gronwall–Bellman’s inequality, 14, 15

**H**

Hamilton–Jacobi–Riccati inequalities, 97  
 Herbivore–plant, xiii  
 $(h_0, h)$ –equi-attractive, 118  
 $(h_0, h)$ –stable, 118  
 $(h_0, h)$ –uniformly asymptotically stable, 118  
 $(h_0, h)$ –uniformly attractive, 118  
 $(h_0, h)$ –uniformly stable, 118  
 Hull, 31  
 Hyperplanes, 3  
 Hypersurfaces, 3–5, 77

**I**

Impulsive delay logarithmic population model, 151, 163  
 Impulsive differential equations, xiii, 1, 2, 33, 97, 108  
   forced Perturbed, 47  
   hyperbolic, 33, 34  
   weakly nonlinear, 41, 113  
    $(h_0, h)$ –stable, 116  
   with time delays, 97, 126  
 Impulsive differential inequalities, 12  
 Impulsive function differential equations, 97, 135  
 Impulsive Hopfield neural networks, 190, 197, 198  
 Impulsive integro-differential equations, 40, 97, 119  
 Impulsive Lasota–Ważewska model, 151  
 Impulsive model of hematopoiesis, 151, 158  
 Infinitesimal operator, 88, 89  
 Initial condition, 3, 6  
 Initial value problem, 3, 4, 6, 8  
 Integral curve, 2, 4, 5  
 Integro-almost periodic, 120  
 Integro-summary equation, 8

**J**

Jump operator, 2

**L**

Lienard’s type equation, 53  
 Limit sequence, 17  
 Limiting systems, 31, 167  
 Linear system, 9, 40  
 Logarithmic Population Model, 163  
 Lotka–Volterra models, xvi  
   impulsive, 151, 166  
   with delays, 181

  with dispersion, 175  
 Lyapunov functions, 10, 151  
   almost periodic, 25, 97, 99  
   continuous, 25  
   piecewise continuous, 1, 10, 11, 33  
 Lyapunov method, 10, 97

**M**

Masera’s type theorem, 99  
 Merging, 4  
 Moments of impulse effect, 2–4  
   fixed, 3, 7, 33, 47  
   variable impulsive perturbations, 4  
 Monotone increasing, 12  
 $\Delta$ – $m$  set, 67

**N**

Neural networks, xvi, 190  
   impulsive, 190, 198, 201  
 Non-decreasing, 13  
 Non-singular transformation, 35

**O**

Ordinary differential equations, 8

**P**

Parasitoid–host, xiii  
 Perturbations in the linear part, 57  
 Population dynamics, 166  
 Positive definite matrix function, 143  
 Predator–prey, xiii  
 Predator–prey system, xiv, xv, 94

**R**

Relatively dense set, 16, 19, 67  
 Response function, xiv  
   prey-dependent, xv  
   ratio-dependent, xv  
 $(r_0, r)$ –uniformly bounded, 118

**S**

Second method of Lyapunov, 10  
 Separated constant, 79  
 Separation, 25  
 Solution(s), 2, 5–7  
   almost periodic, 33, 97, 151  
   unique, 37, 39, 44, 46, 50, 61, 85, 96, 109, 119, 155, 161, 194

- maximal, 12, 13
- minimal, 12
- separated, 76, 79
- Stable, 15, 168
- Strictly positive solution, 168
  - almost periodic, 171
- Strongly stable, 65, 66, 69
- U**
- u-strongly stable, 70
- Uncertain impulsive dynamical equations,
  - 97, 142
- Uniformly almost periodic
  - set of sequences, 23, 24
- Uniformly asymptotically stable, 15, 16,
  - 109, 120, 128
- Uniformly attractive, 15, 16, 120, 128
- Uniformly positive definite matrix function,
  - 144
- Uniformly robustly asymptotically stable,
  - 143, 145, 148
- Uniformly robustly attractive, 143
- Uniformly robustly stable, 143
- Uniformly stable, 15, 16, 120, 127
  - to the left, 68, 69
  - to the right, 68, 69
- Uniqueness, 1, 5, 33, 97