

## A STUDY OF IMPULSIVE FRACTIONAL DIFFERENTIAL INCLUSIONS WITH ANTI-PERIODIC BOUNDARY CONDITIONS

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**Abstract.** In this paper, we prove the existence of solutions for impulsive fractional differential inclusions with anti-periodic boundary conditions by applying Bohnenblust-Karlin's fixed point theorem.

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### REFERENCES

- [1] B. AHMAD, J. J. NIETO, *Existence and approximation of solutions for a class of nonlinear impulsive functional differential equations with anti-periodic boundary conditions*, Nonlinear Anal. **69** (2008), 3291–3298.
- [2] B. AHMAD, J.J. NIETO, *Existence results for nonlinear boundary value problems of fractional integrodifferential equations with integral boundary conditions*, Boundary Value Problems, Article ID 708576 (2009), 11 pages.
- [3] B. AHMAD, S. SIVASUNDARAM, *Existence results for nonlinear impulsive hybrid boundary value problems involving fractional differential equations*, Nonlinear Analysis: Hybrid Systems **3** (2009), 251–258.
- [4] B. AHMAD, V. OTERO-ESPINAR, *Existence of solutions for fractional differential inclusions with anti-periodic boundary conditions*, Boundary Value Problems, Article ID 625347 (2009), 11 pages.
- [5] B. AHMAD, J.J. NIETO, *it Existence results for higher order fractional differential inclusions with nonlocal boundary conditions*, Nonlinear Studies **17** (2010), 131–138.
- [6] B. AHMAD, JUAN J. NIETO, *Existence of solutions for anti-periodic boundary value problems involving fractional differential equations via Leray-Schauder degree theory*, Topological Methods in Nonlinear Analysis **35** (2010), 295–304.
- [7] B. AHMAD, *Some existence results for boundary value problems of fractional semilinear evolution equations*, Electron. J. Qual. Theory Differ. Equ. **28** (2009), 1–7.
- [8] M. BELMEKKI, JUAN J. NIETO, AND R. RODRÍGUEZ-LÓPEZ, *Existence of periodic solution for a nonlinear fractional differential equation*, Boundary Value Problems (2000), Art. ID 324561, 18 pages.
- [9] M. BENCHOHRA, S. HAMANI, *The method of upper and lower solutions and impulsive fractional differential inclusions*, Nonlinear Analysis: Hybrid Systems **3** (2009), 433–440.
- [10] H. F. BOHNENBLUST, S. KARLIN, *On a theorem of Ville*, In Contributions to the Theory of Games Vol. I, pp. 155–160, Princeton Univ. Press, 1950.
- [11] Y.-K. CHANG, J.J. NIETO, *Some new existence results for fractional differential inclusions with boundary conditions*, Mathematical and Computer Modelling **49** (2009), 605–609.
- [12] Y.-K. CHANG, W. T. LI AND J. J. NIETO, *Controllability of evolution differential inclusions in Banach spaces*, Nonlinear Anal. TMA **67** (2007), 623–632.
- [13] Y.-K. CHANG, J.J. NIETO, *Existence of solutions for impulsive neutral integro-differential inclusions with nonlocal initial conditions via fractional operators*, Numerical Func. Anal. Optim. **30** (2009), 227–244.
- [14] Y.-K. CHANG, J.J. NIETO, W.S. LI, *On impulsive hyperbolic differential inclusions with nonlocal initial conditions*, J. Optim. Theory Appl. **140** (2009), 431–442.

- [15] Y. CHEN, J.J. NIETO, D. O'REGAN, *Antiperiodic solutions for fully nonlinear first-order differential equations*, Math. Comput. Modelling **46**, 9-10 (2007), 1183–1190.
- [16] V. DAFTARDAR-GEJJI, S. BHALEKAR, *Boundary value problems for multi-term fractional differential equations*, J. Math. Anal. Appl. **345** (2008), 754–765.
- [17] K. DEIMLING, *Multivalued Differential Equations*, De Gruyter, Berlin, 1992.
- [18] G.H. ERJAEI, S. MOMANI, *Phase synchronization in fractional differential chaotic systems*, Physics Letters A **372** (2008), 2350–2354.
- [19] D. FRANCO, J.J. NIETO, D. O'REGAN, *Anti-periodic boundary value problem for nonlinear first order ordinary differential equations*, Math. Inequal. Appl. **6** (2003), 477–485.
- [20] M. FRIGON, *Systems of first order differential inclusions with maximal monotone terms*, Nonlinear Anal. TMA **66** (2007), 2064–2077.
- [21] V. GAFIYCHUK, B. DATSKO, V. MELESHKO, *Mathematical modeling of time fractional reaction-diffusion systems*, J. Comput. Appl. Math. **220** (2008), 215–225.
- [22] J. HENDERSON, A. OUAHAB, *Fractional functional differential inclusions with finite delay*, Nonlinear Anal. **70** (2009), 2091–2105.
- [23] S. HU, N. PAPAGEORGIOU, *Handbook of Multivalued Analysis*, Kluwer, Dordrecht, Boston, 1997.
- [24] R.W. IBRAHIM, M. DARUS, *Subordination and superordination for univalent solutions for fractional differential equations*, J. Math. Anal. Appl. **345** (2008), 871–879.
- [25] A.A. KILBAS, H.M. SRIVASTAVA, J.J. TRUJILLO, *Theory and Applications of Fractional Differential Equations*, North-Holland Mathematics Studies, 204. Elsevier Science B.V., Amsterdam, 2006.
- [26] S. LADACI, J.L. LOISEAU, A. CHAREF, *Fractional order adaptive high-gain controllers for a class of linear systems*, Commun. Nonlinear Sci. Numer. Simul. **13** (2008), 707–714.
- [27] V. LAKSHMIKANTHAM, D.D. BAINOV, P.S. SIMEONOV, *Theory of Impulsive Differential Equations*, World Scientific, Singapore, 1989.
- [28] V. LAKSHMIKANTHAM, S. LEELA, J. VASUNDHARA DEVI, *Theory of Fractional Dynamic Systems*, Cambridge Academic Publishers, Cambridge, 2009.
- [29] A. LASOTA, Z. OPIAL, *An application of the Kakutani-Ky Fan theorem in the theory of ordinary differential equations*, Bull. Acad. Polon. Sci. Ser. Sci. Math. Astronom. Phys. **13** (1965), 781–786.
- [30] M.P. LAZAREVIĆ, *Finite time stability analysis of PD<sup>α</sup> fractional control of robotic time -delay systems*, Mech. Res. Comm. **33** (2006), 269–279.
- [31] W.S. LI, Y.K. CHANG, J.J. NIETO, *Existence results for impulsive neutral evolution differential inclusions with state-dependent delay*, Math. Comput. Model. **49** (2009), 1920–1927.
- [32] B. LIU, *An anti-periodic LaSalle oscillation theorem for a class of functional differential equations*, J. Comput. Appl. Math. **223** (2009), 1081–1086.
- [33] Z. LUO, J. SHEN, J.J. NIETO, *antiperiodic boundary value problem for first-order impulsive ordinary differential equations*, Comput. Math. Appl. **49** (2005), 253–261.
- [34] J.J. NIETO, R. RODRIGUEZ-LOPEZ, *Euler polygonal method for metric dynamical systems*, Information Sciences **177** (2007), 4256–4270.
- [35] A. OUAHAB, *Some results for fractional boundary value problem of differential inclusions*, Nonlinear Anal. **69** (2008), 3877–3896.
- [36] I. PODLUBNY, *Fractional Differential Equations*, Academic Press, San Diego, 1999.
- [37] S.Z. RIDA, H.M. EL-SHERBINY, A.A.M. ARAFA, *On the solution of the fractional nonlinear Schrödinger equation*, Physics Letters A **372** (2008), 553–558.
- [38] Y.V. ROGOVCHENKO, *Impulsive evolution systems: Main results and new trends*, Dynam. Contin. Discrete Impuls. Systems **3** (1997), 57–88.
- [39] S.G. SAMKO, A.A. KILBAS, O.I. MARICHEV, *Fractional Integrals and Derivatives. Theory and Applications*, Gordon and Breach, Yverdon, 1993.
- [40] A.M. SAMOILENKO, N.A. PERESTYUK, *Impulsive Differential Equations*, World Scientific, Singapore, 1995.
- [41] G.V. SMIRNOV, *Introduction to the theory of differential inclusions*, American Mathematical Society, Providence, RI, 2002.
- [42] S.T. ZAVALISHCHIN, A.N. SESEKIN, *Dynamic Impulse Systems. Theory and Applications*, Kluwer Academic Publishers Group, Dordrecht, 1997.