

IMPLICIT CAPUTO FRACTIONAL q -DIFFERENCE EQUATIONS WITH NON INSTANTANEOUS IMPULSES

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Abstract. In the present article, we prove some existence results for a class of implicit Caputo fractional q -difference equations with non instantaneous impulses in Banach spaces. The used techniques rely on the concepts of measure of noncompactness and the use of suitable fixed point theorems.

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REFERENCES

- [1] S. ABBAS AND M. BENCHOHRA, *Uniqueness and Ulam stabilities results for partial fractional differential equations with not instantaneous impulses*, Appl. Math. Comput. **257** (2015), 190–198.
- [2] S. ABBAS, M. BENCHOHRA, J. R. GRAEF AND J. HENDERSON, *Implicit Fractional Differential and Integral Equations: Existence and Stability*, De Gruyter, Berlin, 2018.
- [3] S. ABBAS, M. BENCHOHRA AND G. M. N’GUÉRÉKATA, *Topics in Fractional Differential Equations*, Springer, New York, 2012.
- [4] S. ABBAS, M. BENCHOHRA AND G. M. N’GUÉRÉKATA, *Advanced Fractional Differential and Integral Equations*, Nova Science Publishers, New York, 2015.
- [5] C. R. ADAMS, *On the linear ordinary q -difference equation*, Annals Math. **30** (1928), 195–205.
- [6] R. AGARWAL, *Certain fractional q -integrals and q -derivatives*, Proc. Camb. Philos. Soc. **66** (1969), 365–370.
- [7] R. P. AGARWAL, S. HRISTOVA, D. O’REGAN, *Non-Instantaneous Impulses in Differential Equations*, Springer, New York, 2017.
- [8] B. AHMAD, *Boundary value problem for nonlinear third order q -difference equations*, Electron. J. Differential Equations **2011** (2011), no. 94, pp 1–7.
- [9] B. AHMAD, S. K. NTOUYAS AND L. K. PURNARAS, *Existence results for nonlocal boundary value problems of nonlinear fractional q -difference equations*, Adv. Difference Equ. **2012**, 2012:140.
- [10] J. C. ALVÁREZ, *Measure of noncompactness and fixed points of nonexpansive condensing mappings in locally convex spaces*, Rev. Real. Acad. Cienc. Exact. Fis. Natur. Madrid **79** (1985), 53–66.
- [11] J. M. AYERBEE TOLEDANO, T. DOMÍNGUEZ BENAVIDES AND G. LÓPEZ ACEDO, *Measures of Noncompactness in Metric Fixed Point Theory*, Operator Theory, Advances and Applications, vol. 99, Birkhäuser, Basel, Boston, Berlin, 1997.
- [12] L. BAI, J. J. NIETO, *Variational approach to differential equations with not instantaneous impulses*, Appl. Math. Lett. **73** (2017), 44–48.
- [13] L. BAI, J. J. NIETO, X. WANG, *Variational approach to non-instantaneous impulsive nonlinear differential equations*, J. Nonlinear Sci. Appl. **10** (2017), 2440–2448.
- [14] J. BANAŠ AND K. GOEBEL, *Measures of Noncompactness in Banach Spaces*, Marcel Dekker, New York, 1980.
- [15] M. BENCHOHRA, J. HENDERSON AND S. K. NTOUYAS, *Impulsive Differential Equations and Inclusions*, Hindawi Publishing Corporation, vol. 2, New York, 2006.
- [16] F. BROWDER, *On the convergence of successive approximations for nonlinear functional equations*, Indag. Math. **30** (1968), 27–35.

- [17] L. BYSZEWSKI, *Theorems about the existence and uniqueness of solutions of a semilinear evolution nonlocal Cauchy problem*, J. Math. Anal. Appl. **162** (1991), 494–505.
- [18] R. D. CARMICHAEL, *The general theory of linear q -difference equations*, American J. Math. **34** (1912), 147–168.
- [19] K. DENG, *Exponential decay of solutions of semilinear parabolic equations with nonlocal initial conditions*, J. Math. Anal. Appl. **179** (1993), 630–637.
- [20] S. ETEMAD, S. K. NTOUYAS AND B. AHMAD, *Existence theory for a fractional q -integro-difference equation with q -integral boundary conditions of different orders*, Mathematics, **7** 659 (2019), 1–15.
- [21] J. R. GRAEF, J. HENDERSON AND A. OUAHAB, *Impulsive Differential Inclusions. A Fixed Point Approach*, De Gruyter, Berlin/Boston, 2013.
- [22] J. HENDERSON, C. TISDELL, *Topological transversality and boundary value problems on time scales*, J. Math. Anal. Appl. **289** (2004), 110–125.
- [23] E. HERNÁNDEZ AND D. O’REGAN, *On a new class of abstract impulsive differential equations*, Proc. Amer. Math. Soc. **141** (2013), 1641–1649.
- [24] V. KAC AND P. CHEUNG, *Quantum Calculus*, Springer, New York, 2002.
- [25] A. A. KILBAS, H. M. SRIVASTAVA AND J. J. TRUJILLO, *Theory and Applications of Fractional Differential Equations*, Elsevier Science B. V., Amsterdam, 2006.
- [26] N. LALEDJ, A. SALIM, J. E. LAZREG, S. ABBAS, B. AHMAD AND M. BENCHOHRA, *On implicit fractional q -difference equations: Analysis and stability*, Math. Methods Appl. Sci. **45** (2022), no. 17, 10775–10797.
- [27] J. MATKOWSKI, *Integrable solutions of functional equations*, Dissertationes Math. **127** (1975), 1–68.
- [28] H. MÖNCH, *Boundary value problems for nonlinear ordinary differential equations of second order in Banach spaces*, Nonlinear Anal. **4** (1980), 985–999.
- [29] M. PIERRI, D. O’REGAN, V. ROLNIK, *Existence of solutions for semi-linear abstract differential equations with not instantaneous*, Appl. Math. Comput. **219** (2013), 6743–6749.
- [30] P. M. RAJKOVIC, S. D. MARINKOVIC AND M. S. STANKOVIC, *Fractional integrals and derivatives in q -calculus*, Appl. Anal. Discrete Math., **1** (2007), 311–323.
- [31] P. M. RAJKOVIC, S. D. MARINKOVIC AND M. S. STANKOVIC, *On q -analogues of Caputo derivative and Mittag-Leffler function*, Fract. Calc. Appl. Anal., **10** (2007), 359–373.
- [32] I. RUS, A. PETRUSEL, G. PETRUSEL, *Fixed Point Theory*, Cluj University Press, Cluj, 2008.
- [33] A. M. SAMOILENKO, N. A. PERESTYUK, *Impulsive Differential Equations*, World Scientific, Singapore, 1995.
- [34] V. E. TARASOV, *Fractional Dynamics: Application of Fractional Calculus to Dynamics of Particles, Fields and Media*, Springer, Heidelberg; Higher Education Press, Beijing, 2010.
- [35] J. M. AYERBE TOLEDANO, T. DOMINGUEZ BENAVIDES AND G. LOPEZ ACEDO, *Measures of Non-compactness in Metric Fixed Point Theory*, Birkhauser, Basel, 1997.
- [36] J. WANG, A. G. IBRAHIM, D. O’REGAN, *Topological structure of the solution set for fractional non-instantaneous impulsive evolution inclusions*, J. Fixed Point Theory Appl. **20** (2018), no. 2, Art. 59, 25 pp.
- [37] J. WANG AND X. LI, *Periodic BVP for integer/fractional order nonlinear differential equations with non-instantaneous impulses*, J. Appl. Math. Comput. **46** (2014), 321–334.
- [38] D. YANG, J. WANG, D. O’REGAN, *A class of nonlinear non-instantaneous impulsive differential equations involving parameters and fractional order*, Appl. Math. Comput. **321** (2018), 654–671.
- [39] X. ZHANG, Y. LI, P. CHEN, *Existence of extremal mild solutions for the initial value problem of evolution equations with non-instantaneous impulses*, J. Fixed Point Theo. Appl. **19** (2017), 3013–3027.
- [40] Y. ZHOU, *Basic Theory of Fractional Differential Equations*, World Scientific, Singapore, 2014.