INFINITELY MANY PERIODIC SOLUTIONS TO A CLASS OF PERTURBED SECOND–ORDER IMPULSIVE HAMILTONIAN SYSTEMS

John R. Graef, Shapour Heidarkhani and Lingju Kong

Abstract. We investigate the existence of infinitely many periodic solutions to a class of perturbed second-order impulsive Hamiltonian systems. Our approach is based on variational methods and critical point theory.

Mathematics subject classification (2010): 34B15, 47J10.

Keywords and phrases: Infinitely many solutions, perturbed Hamiltonian systems, periodic solutions, impulsive systems, critical point theory, variational methods.

REFERENCES

[1] R. P. AGARWAL AND D. O'REGAN, *Multiple nonnegative solutions for second order impulsive differential equations*, Appl. Math. Comput. **114** (2000), 51–59.

[2] L. BAI AND B. DAI, *Application of variational method to a class of Dirichlet boundary value problems with impulsive effects*, J. Franklin Institute **348** (2011), 2607–2624.

[3] L. BAI, B. DAI, AND F. LI, *Solvability of second-order Hamiltonian systems with impulses via variational method*, Appl. Math. Comput. **219** (2013), 7542–7555.

[4] D. BAINOV AND P. SIMEONOV, *Systems with Impulse Effect*, Mathematics and Its Applications, Ellis Horwood, Chichester, 1989.

[5] L. BAO, B. DAI, *Periodic solutions for second order Hamiltonian systems with impulses via the local linking theorem*, Abstr. Appl. Anal. **2014**, Art. ID 250870, 7 pp.

[6] M. BENCHOHRA, J. HENDERSON, AND S. NTOUYAS, *Theory of Impulsive Differential Equations*, Contemp. Math. Appl. 2. Hindawi Publishing Corporation, New York, (2006).

[7] G. BONANNO, B. DI BELLA, AND J. HENDERSON, *Existence of solutions to second-order boundary-value problems with small perturbations of impulses*, Electron. J. Differential Equations **2013** (2013), No. 126, pp. 1–14.

[8] G. BONANNO AND R. LIVREA, *Multiple periodic solutions for Hamiltonian systems with not coercive potential*, J. Math. Anal. Appl. **363** (2010), 627–638.

[9] G. BONANNO AND R. LIVREA, *Periodic solutions for a class of second-order Hamiltonian systems*, Electron. J. Differential Equations **2005** (2005), No. 115, pp. 1–13.

[10] G. BONANNO AND G. MOLICA BISCI, *A remark on perturbed elliptic Neumann problems*, Stud. Univ. "Babeş-Bolyai" Math. **55** (2010), 17–25.

[11] G. BONANNO AND G. MOLICA BISCI, *Infinitely many solutions for a boundary value problem with discontinuous nonlinearities*, Bound. Value Probl. **2009** (2009), 1–20.

[12] D. CHEN AND B. DAI, *Periodic solutions of some impulsive Hamiltonian systems with convexity potentials*, Abstr. Appl. Anal. **2012**, Art. ID 616427, 8 pp.

[13] H. CHEN AND Z. HE, *New results for perturbed Hamiltonian systems with impulses*, Appl. Math. Comput. **218** (2012), 9489–9497.

[14] G. CHEN AND S. MA, *Periodic solutions for Hamiltonian systems without Ambrosetti-Rabinowitz condition and spectrum 0*, J. Math. Anal. Appl. **379** (2011), 842–851.

[15] G. CORDARO, *Three periodic solutions to an eigenvalue problem for a class of second order Hamiltonian systems*, Abstr. Appl. Anal. **18** (2003), 1037–1045.

[16] G. CORDARO AND G. RAO, *Three periodic solutions for perturbed second order Hamiltonian systems*, J. Math. Anal. Appl. **359** (2009), 780–785.

[17] V. Coti-Zelati, I. Ekeland, and E. Sere, *A variational approach to homoclinic orbits in Hamiltonian systems*, Math. Ann. **288** (1990), 133–160.

[18] Y. Ding and C. Lee, *Periodic solutions for Hamiltonian systems*, SIAM J. Math. Anal. **32** (2000), 555–571.

[19] F. Faraci, *Multiple periodic solutions for second order systems with changing sign potential*, J. Math. Anal. Appl. **319** (2006), 567–578.

[20] D. Franco and J. J. Nieto, *Maximum principle for periodic impulsive first order problems*, J. Comput. Appl. Math. **88** (1998), 149–159.

[21] J. R. Graef, S. Heidarkhani, and L. Kong, *Infinitely many solutions for systems of Sturm-Liouville boundary value problems*, Results Math. **66** (2014), 327–341.

[22] J. R. Graef, J. Henderson, and A. Ouahab, *Impulsive Differential Inclusions, A Fixed Point Approach*, De Gruyter Series in Nonlinear Analysis and Applications Vol. 20, De Gruyter, Berlin, 2013.

[23] H. Gu and T. An, *Existence of infinitely many periodic solutions for second-order Hamiltonian systems*, Electron. J. Differential Equations **2013** (2013), No. 251, pp. 1–10.

[24] X. He and X. Wu, *Periodic solutions for a class of nonautonomous second-order Hamiltonian systems*, J. Math. Anal. Appl. **341** (2008), 1354–1364.

[25] S. Heidarkhani, *Infinitely many solutions for systems of n two-point boundary value Kirchhoff-type problems*, Ann. Polon. Math. **107** (2013), 133–152.

[26] M. Izydorek and J. Janczewska, *Homoclinic solutions for a class of second order Hamiltonian systems*, J. Differential Equations **219** (2005), 375–389.

[27] V. Lakshmikantham, D. D. Bainov, and P. S. Simeonov, *Theory of Impulsive Differential Equations*, World Scientific, Singapore, 1989.

[28] E. K. Lee and Y. H. Lee, *Multiple positive solutions of singular two point boundary value problems for second order impulsive differential equation*, Appl. Math. Comput. **158** (2004), 745–759.

[29] F.-f. Liao and J. Sun, *Variational approach to impulsive problems: A survey of recent results*, Abstract Appl. Anal. Vol. **2014**, Article ID 382970, 11 pages.

[30] X. N. Lin and D. Q. Jiang, *Multiple positive solutions of Dirichlet boundary value problems for second order impulsive differential equations*, J. Math. Anal. Appl. **321** (2006), 501–514.

[31] Y. Long, *Nonlinear oscillations for classical Hamiltonian systems with bi-even subquadratic potentials*, Nonlinear Anal. **25** (1995), 1665–1671.

[32] J. Mawhin and M. Willem, *Critical Point Theory and Hamiltonian Systems*, Springer, New York, 1989.

[33] J. J. Nieto and D. O'Regan, *Variational approach to impulsive differential equations*, Nonlinear Anal. Real World Appl. **10** (2009), 680–690.

[34] P. H. Rabinowitz, *Homoclinic orbits for a class of Hamiltonian systems*, Proc. Roy. Soc. Edinburgh **114** (1990), 33–38.

[35] P. H. Rabinowitz, *Variational methods for Hamiltonian systems*, in: Handbook of Dynamical Systems, vol. 1, North-Holland, 2002, Part 1, Chapter 14, pp. 1091–1127.

[36] B. Ricceri, *A general variational principle and some of its applications*, J. Comput. Appl. Math. **113** (2000), 401–410.

[37] A. M. Samoilenko and N. A. Perestyuk, *Impulsive Differential Equations*, World Scientific, Singapore, 1995.

[38] J. Sun, H. Chen and J. J. Nieto, *Infinitely many solutions for second-order Hamiltonian system with impulsive effects*, Math. Comput. Modelling **54** (2011), 544–555.

[39] J. Sun, H. Chen, J. J. Nieto and M. Otero-Novoa, *The multiplicity of solutions for perturbed second-order Hamiltonian systems with impulsive effects*, Nonlinear Anal. **72** (2010), 4575–4586.

[40] J. Sun, H. Chen, and L. Yang, *The existence and multiplicity of solutions for an impulsive differential equation with two parameters via a variational method*, Nonlinear Anal. **73** (2010), 440–449.

[41] C. Tang, *Periodic solutions for nonautonomous second order systems with sublinear nonlinearity*, Proc. Amer. Math. Soc. **126** (1998), 3263–3270.

[42] X. H. Tang and X. Lin, *Homoclinic solutions for a class of second-order Hamiltonian systems*, J. Math. Anal. Appl. **354** (2009), 539–549.

[43] C.-L. Tang and X.-P. Wu, *Periodic solutions for a class of nonautonomous subquadratic second order Hamiltonian systems*, J. Math. Anal. Appl. **275** (2002), 870–882.

[44] X. H. TANG AND L. XIAO, *Homoclinic solutions for a class of second-order Hamiltonian systems*, Nonlinear Anal. **71** (2009), 1140–1152.

[45] Y. TIAN AND W. GE, *Applications of variational methods to boundary-value problem for impulsive differential equations*, Proc. Edinb. Math. Soc. **51** (2008), 509–527.

[46] Z. WANG AND J. ZHANG, *Periodic solutions of a class of second order non-autonomous Hamiltonian systems*, Nonlinear Anal. **72** (2010), 4480–4487.

[47] Z. WANG, J. ZHANG, AND Z. ZHANG, *Periodic solutions of second order non-autonomous Hamiltonian systems with local superquadratic potential*, Nonlinear Anal. **70** (2009), 3672–3681.

[48] J. XIE, J. LI, AND Z. LUO, *Periodic and subharmonic solutions for a class of the second-order Hamiltonian systems with impulsive effects*, Bound. Value Probl. **2015**, 2015:52, 10 pp.

[49] D. ZHANG, Q. WU, AND B. DAI, *Existence and multiplicity of periodic solutions generated by impulses for second-order Hamiltonian system*, Electron. J. Differential Equations **2014** (2014), No. 121, 12 pp.

[50] D. ZHANG AND B. DAI, *Existence of solutions for nonlinear impulsive differential equations with Dirichlet boundary conditions*, Math. Comput. Modelling **53** (2011), 1154–1161.

[51] Q. ZHANG AND C. LIU, *Infinitely many periodic solutions for second order Hamiltonian Systems*, J. Differential Equations **251** (2011), 816–833.

[52] Q. ZHANG AND X. TANG, *New existence of periodic solutions for second order non-autonomous Hamiltonian systems*, J. Math. Anal. Appl. **369** (2010), 357–367.

[53] J. ZHOU AND Y. LI, *Existence of solutions for a class of second order Hamiltonian systems with impulsive effects*, Nonlinear Anal. **72** (2010), 1594–1603.

[54] W. ZOU AND S. LI, *Infinitely many solutions for Hamiltonian systems*, J. Differential Equations **186** (2002), 141–164.

[55] Q. ZHANG AND C. LIU, *Infinitely many periodic solutions for second order Hamiltonian systems*, J. Differential Equations **251** (2011), 816–833.

[56] X. ZHANG AND Y. ZHOU, *Periodic solutions of non-autonomous second order Hamiltonian systems*, J. Math. Anal. Appl. **345** (2008), 929–933.

Differential Equations & Applications
www.ele-math.com
dea@ele-math.com

Differential Equations & Applications
www.ele-math.com
dea@ele-math.com