



Abstract. A 2-factor of a graph G is a 2-regular spanning subgraph of G . We present a survey summarising results on the structure of 2-factors in regular graphs, as achieved by various researchers in recent years.

References

- [1] M. Abreu, R. Aldred, M. Funk, B. Jackson, D. Labbate and J. Sheehan. Graphs and digraphs with all 2-factor isomorphic. *J. Combin. Th. Ser. B*, 92 (2004), no. 2, 395–404.
- [2] M. Abreu, R. Aldred, M. Funk, B. Jackson, D. Labbate and J. Sheehan. Corrigendum to "Graphs and digraphs with all 2-factors isomorphic" [J. Combin. Theory Ser. B 92 (2), (2004), 395–404]. *J. Combin. Th. Ser. B*, 99, (2009), no. 1, 271–273.
- [3] M. Abreu, A. Diwan, B. Jackson, D. Labbate and J. Sheehan. Pseudo 2-Factor Isomorphic Regular Bipartite Graphs. *J. Combin. Th. Ser. B*, 98 (2008), no. 2, 432–442.
- [4] M. Abreu, M. Funk, D. Labbate, F. Romaniello, A construction for a counterexample to the pseudo 2-factor isomorphic graph conjecture. *Discr. Appl. Math.*, 328, (2023), 134–138.
- [5] M. Abreu, J.B. Gauci, D. Labbate, F. Romaniello and J.P. Zerafa, Perfect matchings, Hamiltonian cycles and edge-colourings in a class of cubic graphs, *Ars Math. Contemp.*, 23 (2023), #P3.01
- [6] M. Abreu, D. Labbate, R. Rizzi and J. Sheehan. Odd 2-factored snarks. *European J. Combin.*, 36, (2014), 460–472.
- [7] M. Abreu, D. Labbate and J. Sheehan. Pseudo and strongly pseudo 2-factor isomorphic regular graphs. *European J. Combin.*, 33, (2012), 1847–1856.
- [8] M. Abreu, D. Labbate and J. Sheehan. Irreducible pseudo 2-factor isomorphic cubic bipartite graphs. *Des. Codes Cryptogr.*, 64 (2012), 153–160.
- [9] A. Alahmadi, R.E.L. Aldred, A. Alkenani, R. Hijazi, P. Solè and C. Thomassen, Extending a perfect matching to a Hamiltonian cycle, *Discrete Math. Theor. Comput. Sci.*, 17(1)(2015), 241–254.
- [10] R. Aldred, M. Funk, B. Jackson, D. Labbate and J. Sheehan. Regular bipartite graphs with all 2-factors isomorphic. *J. Combin. Th. Ser. B*, 92 (2004), no. 1, 151–161.

Key words and phrases: Cubic graph, 2-factors, Hamiltonian circuits, Bipartite graphs

AMS (MOS) Subject Classifications: 05C38, 05C45, 05C70, 05C75

- [11] M. Boben. Irreducible (v_3) configurations and graphs. *Discrete Mathematics*, 307, 331–344, (2007).
- [12] G. Brinkmann. Fast generation of cubic graphs. *J. Graph Theory*, 23, (2), (1996), 139–149.
- [13] G. Brinkmann, J. Goedgebeur, J. Hägglund and K. Markström. Generation and properties of snarks. *J. Combin. Theory Ser. B*, 103 (4), (2013).
- [14] G. Brinkmann, J. Goedgebeur. Generation of cubic graphs and snarks with large girth. *J. Graph Theory*, 86(2), (2017), 255–272.
- [15] J.A. Bondy and U.S.R. Murty. *Graph Theory*. Springer Series: Graduate Texts in Mathematics, Vol. 244, 2008.
- [16] K. Coolsaet, S. D'hondt and J. Goedgebeur, House of Graphs 2.0: A database of interesting graphs and more, *Discrete Applied Mathematics*, 325:97-107, (2023). Available at <https://houseofgraphs.org>
- [17] H.S.M. Coxeter. Self-dual configurations and regular graphs. *Bull. Amer. Math. Soc.*, 56(5) (1950), 413–455.
- [18] A.A. Diwan. Disconnected 2-factors in planar cubic bridgeless graphs. *J. Combin. Th. Ser. B*, 84, (2002), 249–259.
- [19] R.J. Faudree, R.J. Gould, and M.S. Jacobson. On the extremal number of edges in 2-factor Hamiltonian graphs. *Graph Theory - Trends in Mathematics*, Birkhäuser (2006), 139–148.
- [20] D.R. Fulkerson. Blocking and anti-blocking pairs of polyhedra. *Math. Programming*, 1 (1971), 168–194.
- [21] M. Funk, B. Jackson, D. Labbate and J. Sheehan. Det-extremal cubic bipartite graphs. *J. of Graph Theory*, 44, (2003), no. 1, 50–64.
- [22] M. Funk, B. Jackson, D. Labbate and J. Sheehan. 2-factor Hamiltonian graphs. *J. of Combin. Th. Ser. B*, 87, (2003), no.1, 138–144.
- [23] M. Funk and D. Labbate. On minimally one-factorable r -regular bipartite graphs. *Discrete Math.*, 216, (2000), 121–137.
- [24] M. Gardner. Mathematical games: Snarks, boojums and other conjectures related to the four-color-map theorem. *Sci. Am.*, 234 (1976), no. 4, 126–130.
- [25] M. Ghandehari and H. Hatami. A note on independent dominating sets and second Hamiltonian cycles (unpublished).
- [26] J. Goedgebeur. Private communication, (2015).
- [27] J. Goedgebeur. A counterexample to the pseudo 2-factor isomorphic graph conjecture. *Discrete Appl. Math.*, 193, (2015), 57–60.
- [28] M. Gorsky and T. Johanni. Private Communication. (2024).

- [29] R. Häggkvist, On F -Hamiltonian graphs, in: J.A. Bondy, U.S.R. Murty (eds.), *Graph Theory and Related Topics*, Academic Press, New York, 1979, 219–231.
- [30] P. Haxell, B. Seamone and J. Verstraete, Independent dominating sets and Hamiltonian cycles. *J. of Graph Theory* 54 (2007), no. 3, 233–244.
- [31] D.A. Holton and J. Sheehan, *The Petersen graph*. Australian Mathematical Society Lecture Series, 7. Cambridge University Press, Cambridge, 1993.
- [32] R. Isaacs. Infinite families on nontrivial trivalent graphs which are not Tait colourable. *Amer. Math. Monthly*, 82 (1975), 221–239.
- [33] M. Kochol. Snarks without small cycles. *J. Combin. Theory Ser. B.*, 67 (1996), no. 1, 34–47.
- [34] D. Labbate. On determinants and permanents of minimally 1-factorable cubic bipartite graphs. *Note Mat.* 20 (2000/01), no. 1, 37–42.
- [35] D. Labbate. On 3-cut reductions of minimally 1-factorable cubic bigraphs. *Discrete Math.*, 231, (2001), 303–310.
- [36] D. Labbate. Characterizing minimally 1-factorable r -regular bipartite graphs. *Discrete Math.*, 248 (2002), no. 1-3, 109–123.
- [37] M. Las Vergnas, Problèmes de couplages et problèmes Hamiltoniens en théorie des graphes, Thesis, University of Paris 6, Paris, 1972.
- [38] C.H.C. Little. A characterization of convertible (0,1)-matrices. *J. Combin. Theory Ser. B*, 18, (1975), 187–208.
- [39] L. Lovász and M.D. Plummer. *Matching Theory*.. Ann. Discrete Math., 29, North-Holland, Amsterdam, 1986.
- [40] V. Martinetti. Sulle configurazioni piane μ_3 . *Annali di Matematica Pura ed Applicata*, Ser. II - 15 1–26 (dall’aprile 1867 al gennaio 1888).
- [41] W. McCuaig. Pólya’s permanent problem. *Electron. J. Combin.*, 11 (2004), no. 1, Research Paper 79, 83 pp. (electronic).
- [42] W. McCuaig. Even dicycles. *J. Graph Theory*, 35 (2000), no. 1, 46–68.
- [43] N. Robertson, P.D. Seymour and R. Thomas. Permanents, Pfaffian orientations, and even directed circuits. *Ann. Math.*, (2) 150 (1999), no. 3, 929–975.
- [44] N. Robertson, P.D. Seymour and R. Thomas. Tutte’s edge-colouring conjecture. *J. Combin. Theory Ser. B*, 70 (1997), no. 1, 166–183.
- [45] F. Romaniello, J.P. Zerafa. Betwixt and Between 2-Factor Hamiltonian and Perfect-Matching-Hamiltonian Graphs. *Electr. Journ. of Math.*, 30 (2), 2023, #P2.5
- [46] P. D. Seymour. Sums of circuits. In *Graph theory and related topics* (Proc. Conf., Univ. Waterloo, Waterloo, Ont., 1977), pages 341–355. Academic Press, New York, 1979.

- [47] J. Sheehan. Private communication, (2000).
- [48] J. Sheehan. Problem Section, in *Proc. Fifth British Combinatorial Conf.* (eds. C.St.J.A. Nash-Williams and J. Sheehan). Congressus Numerantium XV, Utilitas Mathematica Publ. Corp., Winnipeg, 1975, p.691.
- [49] G. Szekeres. Polyhedral decompositions of cubic graphs. *Bull. Austral. Math. Soc.*, 8 (1973), 367–387.
- [50] P.G. Tait. Remarks on the colourings of maps. *Proc. R. Soc. Edinburgh*, 10 (1880), 729.
- [51] A.G. Thomason. Hamiltonian cycles and uniquely 3-edge colourable graphs, in *Advances in Graph Theory* (ed. B. Bollobás). Ann. Discrete Math., 3, (1978), 259–268.
- [52] C. Thomassen. On the number of Hamiltonian cycles in cubic graphs. *Combinatorics, Probability and Computing*, 5, (1996), 437–442.
- [53] C. Thomassen. Independent dominating sets and a second Hamiltonian cycle. *J. Combin. Theory Ser. B*, 72, (1998), 104–109.
- [54] W. T. Tutte. On Hamiltonian circuits. *J. London Math. Soc.*, 21, (1946), 98–101.
- [55] W. T. Tutte. A contribution to the theory of chromatic polynomials. *Canadian J. Math.*, 6 (1954), 80–91.
- [56] C.Q. Zhang. *Integer Flows and Cycle Covers of Graphs*. Marcel Dekker Inc., New York, (1997).