

## NORMALIZED LAPLACIAN SPECTRUM OF SOME $Q$ -CORONAS OF TWO REGULAR GRAPHS

ARPITA DAS AND PRATIMA PANIGRAHI

*Department of Mathematics*  
*Indian Institute of Technology Kharagpur*  
*India, 721302*

**e-mail:** arpita.das1201@gmail.com  
pratima@maths.iitkgp.ernet.in

### Abstract

In this paper we determine the normalized Laplacian spectrum of the  $Q$ -vertex corona,  $Q$ -edge corona,  $Q$ -vertex neighborhood corona, and  $Q$ -edge neighborhood corona of a connected regular graph with an arbitrary regular graph in terms of normalized Laplacian eigenvalues of the original graphs. Moreover, applying these results we find some non-regular normalized Laplacian co-spectral graphs.

**Keywords:** Normalized Laplacian matrix,  $Q$ -vertex corona,  $Q$ -edge corona,  $Q$ -vertex neighborhood corona,  $Q$ -edge neighborhood corona, Kronecker product, Hadamard product.

**2010 Mathematics Subject Classification:** 05C50; 47A75.

### REFERENCES

- [1] A. Banerjee and J. Jost, *On the spectrum of the normalized graph Laplacian*, *Linear Algebra Appl.* **428** (2008) 3015–3022.  
doi:10.1016/j.laa.2008.01.029
- [2] S. Butler and J. Grout, *A construction of cospectral graphs for the normalized Laplacian*, *Electr. J. Combin.* **18** (2011) 231pp.
- [3] F.R.K. Chung, *Spectral Graph Theory* (CBMS. Reg. Conf. Ser. Math. 92, AMS, providence, RI, 1997).
- [4] D. Cvetković, P. Rowlinson and S. Simić, *An Introduction to the Theory of Graph Spectra* (Cambridge University Press, 2009).
- [5] A. Das and P. Panigrahi, *Normalized Laplacian spectrum of different type of coronas of two regular graphs*, *Kragujevac J. Math.* **41** (2017) 57–69.

- [6] A. Das and P. Panigrahi, *Normalized Laplacian spectrum of some subdivision-coronas of two regular graphs*, *Linear and Multilinear Algebra* **65** (2017) 962–972. doi:10.1080/03081087.2016.1217976
- [7] A. Das and P. Panigrahi, *Normalized Laplacian spectrum of some  $R$ -coronas of two regular graphs*, *South. Asian Bull. Math.* **42** (2018) 833–844.
- [8] C. Godsil and G. Royle, *Algebraic Graph Theory* (Springer, New York, 2001).
- [9] F. Harary, *Graph Theory* (Addison-Wesley, Reading, PA, 1969).
- [10] R.A. Horn and C.R. Johnson, *Topics in Matrix Analysis* (Cambridge University Press, Cambridge, 1991).
- [11] J. Huang and S.C. Li, *On the normalised Laplacian spectrum, degree-Kirchhoff index and spanning trees of graphs*, *Bull. Aust. Math. Soc.* **91** (2015) 353–367. doi:10.1017/S0004972715000027
- [12] H.H. Li and J.S. Li, *A note on the normalized Laplacian spectra*, *Taiwanese J. Math.* **15** (2011) 129–139.
- [13] Q. Liu, J.B. Liu and J. Cao, *Further results on resistance distance and Kirchhoff index in electric networks* (*Discrete Dynamics in Nature and Society*, 2016). doi:10.1155/2016/4682527
- [14] C. McLeman and E. McNicholas, *Spectra of coronae*, *Linear Algebra Appl.* **435** (2011) 998–1007. doi:10.1016/j.laa.2011.02.007
- [15] E.R. Vandam and W.H. Haemers, *Which graphs are determined by their spectrum?*, *Linear Algebra Appl.* **373** (2003) 241–272. doi:10.1016/S0024-3795(03)00483-X

Received 28 January 2019  
Revised 19 September 2019  
Accepted 11 October 2020