INEQUALITIES ON THE ESSENTIAL JOINT AND ESSENTIAL GENERALIZED SPECTRAL RADIUS

BRIAN LINS AND ALJOŠA PEPERKO*

Abstract. We prove new inequalities for the essential generalized and the essential joint spectral radius of Hadamard (Schur) weighted geometric means of bounded sets of infinite nonnegative matrices that define operators on suitable Banach sequence spaces and of bounded sets of positive kernel operators on L^2 . To our knowledge the obtained inequalities are new even in the case of singelton sets.

Mathematics subject classification (2020): 47A10, 47B65, 47B34, 15A42, 15A60, 15B48.

Keywords and phrases: Weighted Hadamard-Schur geometric mean, Hadamard-Schur product, essential spectral radius, Haussdorf measure of noncompactness, joint and generalized spectral radius, positive kernel operators, non-negative matrices, bounded sets of operators.

REFERENCES

- [1] Y. A. ABRAMOVICH AND C. D. ALIPRANTIS, *An invitation to operator theory*, American Mathematical Society, Providence, 2002.
- [2] C. D. ALIPRANTIS AND O. BURKINSHAW, *Positive operators*, Reprint of the 1985 original, Springer, Dordrecht, 2006.
- [3] K. M. R. AUDENAERT, Spectral radius of Hadamard product versus conventional product for nonnegative matrices, Linear Algebra Appl. 432 (2010), 366–368.
- [4] C. BENNETT AND R. SHARPLEY, Interpolation of Operators, Academic Press, Inc., Orlando, 1988.
- [5] K. BOGDANOVIĆ, Inequalities on the generalized and the joint spectral radius of bounded sets of positive operators on Banach function and sequence spaces, preprint (2023), arXiv:2311.02444v1
- [6] K. BOGDANOVIĆ AND A. PEPERKO, Hadamard weighted geometric mean inequalities for the spectral and essential spectral radius of positive operators on Banach function and sequence spaces, Positivity 26, Article number: 25 (2022).
- [7] K. BOGDANOVIĆ AND A. PEPERKO, Inequalities and equalities on the joint and generalized spectral and essential spectral radius of the Hadamard geometric mean of bounded sets of positive kernel operators, Linear Mult. Algebra (2022), https://doi.org/10.1080/03081087.2022.2121369.
- [8] D. CHEN AND Y. ZHANG, On the spectral radius of Hadamard products of nonnegative matrices, Banach J. Math. Anal. 9 (2015), 127–133.
- [9] G. P. CURBERA AND W.. RICKER, Compactness properties of Sobolev imbeddings for rearrangement invariant norms, Transactions AMS 359 (2007), 1471–1484.
- [10] X. DAI, Extremal and Barabanov semi-norms of a semigroup generated by a bounded family of matrices, J. Math. Anal. Appl. 379 (2011), 827–833.
- [11] R. DRNOVŠEK, Sequences of bounds for the spectral radius of a positive operator, Linear Algebra Appl. 574 (2019), 40–45.
- [12] R. DRNOVŠEK AND A. PEPERKO, Inequalities for the Hadamard weighted geometric mean of positive kernel operators on Banach function spaces, Positivity 10 (2006), 613–626.
- [13] R. DRNOVŠEK AND A. PEPERKO, On the spectral radius of positive operators on Banach sequence spaces, Linear Algebra Appl. **433** (2010), 241–247.
- [14] R. DRNOVŠEK AND A. PEPERKO, Inequalities on the spectral radius and the operator norm of Hadamard products of positive operators on sequence spaces, Banach J. Math. Anal. 10 (2016), 800– 814.



- [15] L. ELSNER, D. HERSHKOWITZ AND A. PINKUS, Functional inequalities for spectral radii of nonnegative matrices, Linear Algebra Appl. 129 (1990), 103–130.
- [16] L. ELSNER, C. R. JOHNSON AND J. A. DIAS DA SILVA, The Perron root of a weighted geometric mean of nonnegative matrices, Linear Mult. Algebra 24 (1988), 1–13.
- [17] P. A. FILLMORE, J. G. STAMPFLI AND J. P. WILLIAMS, On the essential numerical range, the essential spectrum, and a problem of Halmos, Acta Sci. Math. (Szeged) 33 (1972), 179–192.
- [18] P. S. GUINAND, On quasinilpotent semigroup of operators, Proc. Amer. Math. Soc. 86 (1982), 485– 486.
- [19] R. A. HORN AND F. ZHANG, Bounds on the spectral radius of a Hadamard product of nonnegative or positive semidefinite matrices, Electron. J. Linear Algebra 20 (2010), 90–94.
- [20] Z. HUANG, On the spectral radius and the spectral norm of Hadamard products of nonnegative matrices, Linear Algebra Appl. 434 (2011), 457–462.
- [21] K. JÖRGENS, *Linear integral operators*, Surveys and Reference Works in Mathematics 7, Pitman Press, 1982.
- [22] A. V. KAZHIKHOV AND A. E. MAMONTOV, Transport equations and Orlicz spaces, 535–544, in: Jeltsch R., Fey M. (eds) Hyperbolic Problems: Theory, Numerics, Applications. International Series of Numerical Mathematics, vol. 130, Birkhäuser, Basel, 1999.
- [23] P. MEYER-NIEBERG, Banach lattices, Springer-Verlag, Berlin, 1991.
- [24] I. D. MORRIS, The generalized Berger-Wang formula and the spectral radius of linear cocycles, J. Funct. Anal. 262 (2012), 811–824.
- [25] D. S. MITRINOVIĆ, Analitic Inequalities, Springer Verlag, Berlin Heidelberg New York, 1970.
- [26] V. MÜLLER AND A. PEPERKO, Generalized spectral radius and its max algebra version, Linear Algebra Appl. 439 (2013), 1006–1016.
- [27] R. D. NUSSBAUM, The radius of the essential spectrum, Duke Math. J. 37 (1970), 473–478.
- [28] A. PEPERKO, On the max version of the generalized spectral radius theorem, Linear Algebra Appl. 428 (2008), 2312–2318.
- [29] A. PEPERKO, Inequalities for the spectral radius of non-negative functions, Positivity 13 (2009), 255– 272.
- [30] A. PEPERKO, On the functional inequality for the spectral radius of compact operators, Linear Mult. Algebra 59 (2011), no. 4, 357–364.
- [31] A. PEPERKO, Bounds on the generalized and the joint spectral radius of Hadamard products of bounded sets of positive operators on sequence spaces, Linear Algebra Appl. 437 (2012), 189–201.
- [32] A. PEPERKO, Bounds on the joint and generalized spectral radius of the Hadamard geometric mean of bounded sets of positive kernel operators, Linear Algebra Appl. 533 (2017), 418–427.
- [33] A. PEPERKO, Inequalities on the spectral radius, operator norm and numerical radius of the Hadamard products of positive kernel operators, Linear Mult. Algebra 67:8 (2019), 1637–1652.
- [34] A. PEPERKO, Inequalities on the joint and generalized spectral and essential spectral radius of the Hadamard geometric mean of bounded sets of positive kernel operators, Linear Mult. Algebra 67 (2019), no. 11, 2159–2172.
- [35] A. PEPERKO, Inequalities for the spectral radius and essential spectral radius of positive operators on Banach sequence spaces, Positivity 25 (4) (2021), 1659–1675.
- [36] A. R. SCHEP, Bounds on the spectral radius of Hadamard products of positive operators on l_p-spaces, Electronic J. Linear Algebra 22 (2011), 443–447.
- [37] A. R. SCHEP, Corrigendum for "Bounds on the spectral radius of Hadamard products of positive operators on l_p-spaces", (2011), preprint at Research gate: Corrigendum-Hadamard.
- [38] S.-Q. SHEN AND T.-Z. HUANG, Several inequalities for the largest singular value and spectral radius of matrices, Mathematical Inequalities and Applications 1013 (2004), 1–9.
- [39] M.-H. SHIH, J.-W. WU AND C.-T. PANG, Asymptotic stability and generalized Gelfand spectral radius formula, Linear Algebra Appl. 252 (1997), 61–70.
- [40] V. S. SHULMAN AND YU. V. TUROVSKII, Joint spectral radius, operator semigroups and a problem of W. Wojtyński, J. Funct. Anal. 177 (2000), 383–441.
- [41] V. S. SHULMAN AND YU. V. TUROVSKII, Application of topological radicals to calculation of joint spectral radii, preprint (2008), arxiv:0805.0209v1
- [42] J. G. STAMPFLI, Hyponormal operators, Pacific J. Math. 12 (1962), 1453–1458.
- [43] F. WIRTH, *The generalized spectral radius and extremal norms*, Linear Algebra Appl. **342** (2002), 17–40.

- [44] A. C. ZAANEN, Riesz Spaces II, North Holland, Amsterdam, 1983.
- [45] X. ZHAN, Unsolved matrix problems, talk given at Advanced Workshop on Trends and Developments in Linear Algebra, ICTP, Trieste, Italy, July 6–10, 2009.
- [46] Y. ZHANG, Some spectral norm inequalities on Hadamard products of nonnegative matrices, Linear Algebra Appl. 556 (2018), 162–170.