

# SOME REFINEMENTS OF REAL POWER FORM INEQUALITIES FOR $(p,h)$ -CONVEX FUNCTIONS VIA WEAK SUB-MAJORIZATION

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**Abstract.** The main goal of this paper, is to develop a general method for improving some new real power inequalities for  $(p,h)$ -convex and  $(p,h)$ -log-convex functions, which extends and unifies two recent and important results due to M. A. Ighachane and M. Bouchangour, (*Filomat*, **37** (16), (2023), 5259–5271) and (*Operators and Matrices*, **17** (1), (2023), 213–233). As applications of our results, we present further inequalities for the symmetric norms for  $\tau$ -measurable operators.

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## REFERENCES

- [1] H. ALZER, C. M. FONSECA AND A. KOVAČEC, *Young-type inequalities and their matrix analogues*, Linear and Multilinear Algebra., **63** (3), (2015), 622–635.
- [2] M. U. AWAN, N. AKHTAR, S.IFTIKHAR, M. A. NOOR AND Y.-M. CHU, *New Hermite-Hadamard type inequalities for  $n$ -polynomial harmonically convex functions*, Journal of Inequalities and Applications, **15**, (2020).
- [3] P. G. DODDS, T. K. DODDS AND F. A. SUKOCHEV, *On  $p$ -convexity and  $q$ -concavity in noncommutative symmetric spaces*, Integral Equ. Oper. Theory, **78**, (2014), 91–114.
- [4] Z. B. FANG AND R. SHI, *On the  $(p,h)$ -convex function and some integral inequalities*, J. Inequal. Appl., **2014**, 45, (2014), <https://doi.org/10.1186/1029-242X-2014-45>.
- [5] T. FACK, H. KOSAKI, *Generalized  $s$ -numbers of  $\tau$ -measurable operators*, Pac. J. Math., **123**, (1986), 269–300.
- [6] D. Q. HUY, D. T. T. VAN AND D. T. XINH, *Some generalizations of real power form for Young-type inequalities and their applications*, Linear Algebra App., **656**, (2023), 368–384.
- [7] M. A. IGHACHANE AND M. BOUCHANGOUR, *New inequalities for  $(p,h)$ -convex functions for  $\tau$ -measurable operators*, Filomat, **37** (16), (2023), 5259–5271.
- [8] M. A. IGHACHANE AND M. BOUCHANGOUR, *Some refinements of real power form inequalities for convex functions via weak sub-majorization*, Oper. Matrices, **17** (1), (2023), 213–233.
- [9] M. A. IGHACHANE, Z. TAKI AND M. BOUCHANGOUR, *An improvement of Alzer-Fonseca-Kovačec's type inequalities with applications*, Filomat, **37** (22) (2023), 7383–7399.
- [10] İ. İSCAN, *Hermite-Hadamard type inequalities for harmonically convex functions*, Hacet. J. Math. Stat., **43** (6), (2014), 935–942.
- [11] F. KITTANEH AND Y. MANASRAH, *Improved Young and Heinz inequalities for matrices*, J. Math. Anal. Appl. **361** (1), (2010), 262–269.
- [12] Y. MANASRAH AND F. KITTANEH, *A generalization of two refined Young inequalities*, Positivity, **19** (4), (2015), 757–768.
- [13] A. W. MARSHALL, I. OLKIN AND B. C. ARNOLD, *Inequalities: Theory of majorization and its applications*, second edition, Springer Series in Statistics, Springer, New York (2011).
- [14] F. MIRZAPOUR AND A. MORASSAEI, *Inequalities for  $h$ -log-convex functions*, Rocky Mountain J. Math., **52** (3), (2022), 1009–1020.

- [15] G. PISIER, Q. XU, *Non-commutative  $L_p$  spaces*, Handbook of the geometry of Banach spaces., **2**, (2003), 1459–1517.
- [16] J. SHAO, *Two variables functionals and inequalities related to measurable operators*, Journal. Inequ. Appl., **304**, (2017), <https://doi.org/10.1186/s13660-017-1583-9>.
- [17] M. SABABHEH, *Convexity and matrix means*, Linear Algebra App., **506**, (2016), 588–602.
- [18] M. SABABHEH AND H. R. MORADI, *Radical convex functions*, Mediterr. J. Math., 18:137, (2021).
- [19] Q. XU, *Analytic functions with values in lattices and symmetric spaces of measurable operators*, Math. Proc. Camb. Philos. Soc., **109**, (1991), 541–563.
- [20] K. S. ZHANG AND J. P. WAN,  *$p$ -convex functions and their properties*, Pure Appl. Math., **23** (1), (2007), 130–133.