

WEIGHTED INEQUALITIES FOR HARMONIC MEANS

P. ORTEGA SALVADOR AND C. RAMÍREZ TORREBLANCA

Abstract. We characterize the weighted weak and strong type (p, q) inequalities for the harmonic averaging operator

$$Tf(x) = \frac{x}{\int_0^x \frac{1}{f}}$$

in the cases $0 < p \leq q < \infty$ and $0 < q < p < \infty$.

Mathematics subject classification (2000): 26D15, 42B25.

Key words and phrases: Hardy inequalities, weights, weighted inequalities, harmonic means.

REFERENCES

- [1] K. F. ANDERSEN AND B. MUCKENHOUT, *Weighted weak type Hardy inequalities with applications to Hilbert transforms and maximal functions*, *Studia Math.* **72** (1982), 9–26.
- [2] A. L. BERNARDIS, F. J. MARTÍN-REYES AND P. ORTEGA SALVADOR, *A new proof of the characterization of the weighted Hardy inequality*, preprint (2004).
- [3] J. BRADLEY, *Hardy inequalities with mixed norms*, *Canad. Math. Bull.* **21** (1978), 405–408.
- [4] P. S. BULLEN, *Handbook of means and their inequalities*, Kluwer Academic Pub., 2003.
- [5] P. S. BULLEN, D. S. MITRINOVIC AND P. M. VASIC (EDS.), *Means and Their Inequalities*, D. Reidel Publishing Company, 1988.
- [6] D. CRUZ-URIBE, S.F.O., C. J. NEUGEBAUER AND V. OLESEN, *The one-sided minimal operator and the one-sided reverse Hölder inequality*, *Studia Math.* **116** no. 3 (1995), 255–270.
- [7] H. P. HEINIG, R. KERMAN AND M. KRBEČ, *Weighted exponential inequalities*, *Georgian Math. J.* **8** no. 1 (2001), 69–86.
- [8] A. KUFNER AND L. E. PERSSON, *Weighted inequalities of Hardy type*, World Scientific, 2003.
- [9] P. JAIN, L.E. PERSSON AND A. WEDESTIG, *Carleman-Knopp type inequalities via Hardy inequalities*, *Mathematical Inequalities and Applications* **4** no. 3 (2001), 343–356.
- [10] F. J. MARTÍN-REYES, *New proofs of weighted inequalities for the one-sided Hardy-Littlewood maximal functions*, *Proc. Amer. Math. Soc.* **117** (1993), 691–698.
- [11] F. J. MARTÍN-REYES AND P. ORTEGA SALVADOR, *On weighted weak type inequalities for modified Hardy operators*, *Proc. Amer. Math. Soc.* **126** no. 6 (1998), 1739–1746.
- [12] F. J. MARTÍN-REYES, P. ORTEGA SALVADOR AND M. D. SARRIÓN GAVILÁN, *Boundedness of operators of Hardy type in $L^{p,q}$ spaces and weighted mixed inequalities for singular integral operators*, *Proc. Roy. Soc. Edinburgh Sect. A* **127** (1997), 157–170.
- [13] F. J. MARTÍN-REYES AND A. DE LA TORRE, *Some weighted inequalities for general one-sided maximal operators*, *Studia Math.* **122** (1997), 1–14.
- [14] V. G. MAZ'JA, *Sobolev Spaces*, Springer-Verlag Berlin Heidelberg New York Tokyo, 1985.
- [15] B. OPIC AND P. GURKA, *Weighted inequalities for geometric means*, *Proc. Amer. Math. Soc.* **120** no. 3 (1994), 771–779.
- [16] B. OPIC AND A. KUFNER, *Hardy-type inequalities*, Longman, 1990.
- [17] L. PICK AND B. OPIC, *On the geometric mean operator*, *J. Math. Anal. Appl.* **183** (1994), 652–662.
- [18] QINSHENG LAI, *Weighted modular inequalities for Hardy type operators*, *Proc. London Math. Soc.* **79** no. 3 (1999), 649–672.

- [19] E. SAWYER, *Weighted Lebesgue and Lorentz norm inequalities for the Hardy operator*, Trans. Amer. Math. Soc. **281** (1984), 329–337.
- [20] G. SINNAMON, *Operators on Lebesgue spaces with general measures*, Doctoral Thesis, McMaster University, 1987.