

## COMMUTATORS GENERATED BY BMO-FUNCTIONS AND THE FRACTIONAL INTEGRALS ON ORLICZ-MORREY SPACES

TAKESHI IIDA

**Abstract.** We study the boundedness of commutators generated by BMO functions and the fractional integral operator on Orlicz-Morrey spaces of the second kind. To show this problem, we investigate the Fefferman-Stein type inequality concerning the Hardy-Littlewood maximal function and the sharp maximal operator and the boundedness of the Orlicz-fractional maximal operator in the Orlicz-Morrey spaces.

*Mathematics subject classification (2020):* 26A33, 42B25, 42B35.

*Keywords and phrases:* Orlicz-Morrey spaces, commutators, fractional integral operator, Orlicz maximal operator, Orlicz-fractional maximal operator.

### REFERENCES

- [1] D. ADAMS, *A note on Riesz potentials*, Duke Math. J., 42, 1975, 765–778.
- [2] E. BURTSEVA, L. MALIGRANDA AND K. MATSUOKA, *Boundedness of the Riesz potential in central Morrey-Orlicz spaces*, Positivity, 26, 1, 22, 2022, 26 pp.
- [3] D. CRUZ-URIBE, SFO AND A. FIORENZA, *Endpoint estimates and weighted norm inequalities for commutators of fractional integrals*, Publ. Mat. 47, 2003, 103–131.
- [4] D. CRUZ-URIBE, SFO AND K. MOEN, *A fractional Muckenhoupt-Wheeden theorem and its consequences*, Integral Equations Operator Theory, 76, 2013, 3, 421–446.
- [5] D. CRUZ-URIBE, SFO, JOSÉ MARÍA MARTELL AND C. PÉREZ, *Weights, extrapolation and the theory of Rubio de Francia*. Operator Theory: Advances and Applications, 215. Birkhäuser/Springer Basel AG, Basel, 2011. xiv+280 pp.
- [6] D. CRUZ-URIBE, SFO AND S. RODNEY, *Bounded weak solutions to elliptic PDE with data in Orlicz spaces*, J. Diff. Eq., 297, 2021, 409–432.
- [7] F. DERINGOZ, V. S. GULIYEV AND S. G. HASANOV, *Maximal operator and its commutators on generalized weighted Orlicz-Morrey spaces*, Tokyo J. Math., 41, 2, 2018, pp. 347–369, doi:10.3836/tjm/1502179260.
- [8] G. DI FAZIO AND M. A. RAGUSA, *Commutators and Morrey spaces*, Boll. Un. Mat. Ital., A 7, 5, 1991, 3, 323–332.
- [9] C. FEFFERMAN AND E. M. STEIN,  *$H^p$  spaces of several variables*, Acta Math., 129, 1972, 137–193.
- [10] S. GALA, Y. SAWANO AND H. TANAKA, *A remark on two generalized Orlicz-Morrey spaces*, J. Approx. Theory, 198 2015, 1–9.
- [11] L. GRAFAKOS, *Classical Fourier analysis*, Third Edition, Graduate Texts in Math., no. 249, Springer, New York, 2014. xviii+638 pp.
- [12] L. GRAFAKOS, *Modern Fourier analysis*, Third Edition, Graduate Texts in Math., no. 250, Springer, New York, 2014. xvi+624pp.
- [13] V. S. GULIYEV, S. G. HASANOV, Y. SAWANO AND T. NOI, *Non-smooth atomic decompositions for generalized Orlicz-Morrey spaces of the third kind*, Acta Appl. Math., 145, 2016, 137–174, doi:10.1007/s10440-016-0052-7.
- [14] N. HATANO, R. KAWASUMI, Y. SAWANO, *Sparse non-smooth atomic decomposition of quasi-Banach lattices*, J. Fourier Anal. Appl. 28, 2022, 4, no. 61, 21 pp.
- [15] T. IIDA, *Orlicz-fractional maximal operators in Morrey and Orlicz-Morrey Spaces*, Positivity, 25, 2021, 243–272, doi:10.1007/s11117-020-00762-w.

- [16] T. IIDA AND Y. SAWANO, *Orlicz-fractional maximal operators on weighted  $L^p$  spaces*, J. Math. Inequal., 13, 2019, 2, 369–413.
- [17] Y. KOMORI AND T. MIZUHARA, *Notes on commutators and Morrey spaces*, Hokkaido Math. J. 32, 2003, 2, 345–353.
- [18] L. MALIGRANDA AND K. MATSUOKA, *Maximal function in Beurling-Orlicz and central Morrey-Orlicz spaces*, Colloq. Math. 138, 2, 2015, 165–181.
- [19] L. MALIGRANDA AND K. MATSUOKA, *Calderón-Zygmund singular integrals in central Morrey spaces*, Tohoku. Math. J., 2, 72, 2, 2020, 235–259.
- [20] C. B. MORREY, *On the solutions of quasi-linear elliptic partial differential equations*, Trans. Amer. Math. Soc. 43, 1938, 1, 126–166.
- [21] E. NAKAI, *Generalized fractional integrals on Orlicz-Morrey spaces*, Banach and function spaces, Yokohama publ., Yokohama, 2004, 323–333.
- [22] S. NAKAMURA AND Y. SAWANO, *The singular integral operator and its commutator on weighted Morrey spaces*, Collect. Math., 68, 2017, 2, 145–174, doi:10.1007/s13348-017-0193-7.
- [23] W. ORLICZ, *Über eine gewisse Klasse von Räumen vom Typus B*, Bull. Acad. Polonaise A (1932), 207–220; reprinted in his Collected Papers, PWN, Warszawa 1988, 217–230 (German).
- [24] W. ORLICZ, *Über Räume( $L^M$ )*, Bull. Acad. Polonaise A (1936), 93–107; reprinted in his Collected Papers, PWN, Warszawa (1988), 345–359 (German).
- [25] C. PÉREZ, *On sufficient conditions for the boundedness of the Hardy-Littlewood maximal operator between weighted  $L^p$ -spaces with different weights*, Proc. London Math. Soc. 3, 71, 1, 1995, 135–157.
- [26] M. M. RAO AND Z. D. REN, *Theory of Orlicz spaces*, Monographs and Textbooks in Pure and Applied Mathematics, 146, Marcel Dekker Inc., New York, 1991. xii+449 pp.
- [27] Y. SAWANO AND D. I. HAKIM, *Complex interpolation and commutators acting on Morrey spaces*, Rom. J. Math. Comput. Sci. 11, 2021, 1, 10–24.
- [28] Y. SAWANO AND H. TANAKA, *Sharp maximal inequalities and commutators on Morrey spaces with non-doubling measures*, Taiwanese J. Math. 11, 4, 2007, 1091–1112.
- [29] Y. SAWANO, G. DI. FAZIO AND D. I. HAKIM, *Morrey spaces-introduction and applications to integral operators and PDE's*, Vol. I. Monographs and Research Notes in Mathematics. CRC Press, Boca Raton, FL, 2020. xxi+479 pp.
- [30] Y. SAWANO, G. DI. FAZIO AND D. I. HAKIM, *Morrey spaces-introduction and applications to integral operators and PDE's*, Vol. II. Monographs and Research Notes in Mathematics. CRC Press, Boca Raton, FL, 2020. xxi+409 pp.
- [31] Y. SAWANO, S. SUGANO AND H. TANAKA, *Orlicz-Morrey spaces and fractional operators*, Potential Analysis, 36, 4, 2012, 517–556.