

GLOBAL REGULARITY IN PARABOLIC WEIGHTED ORLICZ–MORREY SPACES OF SOLUTIONS TO PARABOLIC EQUATIONS WITH VMO COEFFICIENTS

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Abstract. We show continuity in parabolic generalized weighted Orlicz–Morrey spaces $M_w^{\Phi,\varphi}$ of sublinear integral operators generated by parabolic singular and nonsingular operators and their commutators with BMO functions. The obtained estimates are used to study global regularity of the solution of the Cauchy–Dirichlet problem for linear uniformly parabolic operators of second order with discontinuous data.

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REFERENCES

- [1] A. A. AHMADLI, A. AKBULUT, F. A. ISAYEV, A. SERBETCI, *Multilinear commutators of parabolic Calderón–Zygmund operators on generalized weighted variable parabolic Morrey spaces*, Trans. Natl. Acad. Sci. Azerb. Ser. Phys.-Tech. Math. Sci., Mathematics **41** (4), 3–16 (2021).
- [2] M. BRAMANTI, M. C. CERUTTI, $W_p^{1,2}$ solvability for the Cauchy–Dirichlet problem for parabolic equations with VMO coefficients, Comm. in Partial Diff. Eq. **18**, 1735–1763 (1993).
- [3] V. I. BURENKOV, A. GOGATISHVILI, V. S. GULIYEV, R. MUSTAFAYEV, *Boundedness of the fractional maximal operator in local Morrey-type spaces*, Complex Var. Elliptic Equ. **55** (8–10), 739–758 (2010).
- [4] S. BYUN, M. LEE, Weighted estimates for nondivergence parabolic equations in Orlicz spaces, J. Funct. Anal. **268**, 2530–2563 (2015).
- [5] A. P. CALDERÓN, A. ZYGMUND, *Singular integral operators and differential equations*, Amer. J. Math. **79**, 901–921 (1957).
- [6] F. CHIARENZA, M. FRASCA, P. LONGO, $W^{2,p}$ -solvability of Dirichlet problem for nondivergence elliptic equations with VMO coefficients, Trans. Amer. Math. Soc. **336**, 841–853 (1993).
- [7] F. DERİNGÖZ, V. S. GULIYEV, S. G. HASANOV, Maximal operator and its commutators on generalized weighted Orlicz–Morrey spaces, Tokyo J. Math. **41** (2), 347–369 (2018).
- [8] H. DONG, D. KIM, *Parabolic and elliptic systems in divergence form with variably partially BMO coefficients*, SIAM J. Math. Anal. **43**, 1075–1098 (2011).
- [9] J. DUOANDIKOETXEA, *Fourier analysis*, Translated and revised from the 1995 Spanish original by David Cruz-Uribe, Graduate Studies in Mathematics, 29. American Mathematical Society, Providence (2001).
- [10] I. EKİNCIOĞLU, S. UMARKHADZHIEV, Oscillatory integrals with variable Calderón–Zygmund kernel on generalized weighted Morrey spaces, Trans. Natl. Acad. Sci. Azerb. Ser. Phys.-Tech. Math. Sci., Mathematics **42** (1), 99–110 (2022).
- [11] G. DI FAZIO, D. I. HAKIM, Y. SAWANO, *Elliptic equations with discontinuous coefficients in generalized Morrey spaces*, Eur. J. Math. **3** (3), 728–762 (2017).

- [12] G. DI FAZIO, D. K. PLAGACHEV, M. A. RAGUSA, *Global Morrey regularity of strong solutions to the Dirichlet problem for elliptic equations with discontinuous coefficients*, J. Funct. Anal. **166** (2), 179–196 (1999).
- [13] A. FIORENZA, M. KRBEČ, *Indices of Orlicz spaces and some applications*, Comment. Math. Univ. Carolin. **38** (3), 433–451 (1997).
- [14] G. GILBARG, N. S. TRUDINGER, *Elliptic partial differential equations of second order*, 2nd ed., Springer-Verlag (1983).
- [15] A. GOGATISHVILI, V. KOKILASHVILI, *Criteria of weighted inequalities in Orlicz classes for maximal functions defined on homogeneous type spaces*, Georgian Math. J. **1** (6), 641–673 (1994).
- [16] L. GRAFAKOS, *Modern Fourier Analysis*, Graduate Texts in Mathematics, **250**, Springer, New York (2014).
- [17] V. S. GULIYEV, *Integral operators on function spaces on the homogeneous groups and on domains in \mathbb{R}^n* , (in Russian), Doctor's degree dissertation, Mat. Inst. Steklov, Moscow, 329 pp. (1994).
- [18] V. S. GULIYEV, *Boundedness of the maximal, potential and singular operators in the generalized Morrey spaces*, J. Inequal. Appl. Art. ID 503948, 20 pp. (2009).
- [19] V. S. GULIYEV, *Commutators of multilinear Calderón-Zygmund operators with kernels of Dini's type on generalized weighted Morrey spaces and applications*, Positivity **27** (1), Paper No. 13., 29 pp. (2023).
- [20] V. S. GULIYEV, *Generalized weighted Morrey spaces and higher order commutators of sublinear operators*, Eurasian Math. J. **3** (3), 33–61 (2012).
- [21] V. S. GULIYEV, *Local generalized Morrey spaces and singular integrals with rough kernel*, Azerb. J. Math. **3** (2), 79–94 (2013).
- [22] V. S. GULIYEV, A. A. AHMADLI, M. N. OMAROVA, L. G. SOFTOVA, *Global regularity in Orlicz-Morrey spaces of solutions to nondivergence elliptic equations with VMO coefficients*, Electron. J. Differential Equations Paper No. 110, 24 pp. (2018).
- [23] V. S. GULIYEV, A. F. ISMAYILOVA, *Calderón-Zygmund operators with kernels of Dini's type and their multilinear commutators on generalized weighted Morrey spaces*, TWMS J. Pure Appl. Math. **12** (2), 265–277 (2021).
- [24] V. S. GULIYEV, F. DERINGÖZ, *Riesz potential and its commutators on generalized weighted Orlicz-Morrey spaces*, Math. Nachr. **295** (4), 706–724 (2022).
- [25] V. S. GULIYEV, I. EKİNCİOĞLU, A. AHMADLI, M. OMAROVA, *Global regularity in Orlicz-Morrey spaces of solutions to parabolic equations with VMO coefficients*, J. Pseudo-Differ. Oper. Appl. **11** (4), 1963–1989 (2020).
- [26] V. S. GULIYEV, L. SOFTOVA, *Global regularity in generalized weighted Morrey spaces of solutions to nondivergence elliptic equations with VMO coefficients*, Potential Anal. **38** (4), 843–862 (2013).
- [27] V. S. GULIYEV, M. N. OMAROVA, *Estimates for operators on generalized weighted Orlicz-Morrey spaces and their applications to non-divergence elliptic equations*, Positivity **26** (2022), no. 2, Paper No. 40, 27 pp.
- [28] V. S. GULIYEV, SH. A. MURADOVA, M. N. OMAROVA, L. SOFTOVA, *Gradient estimates for parabolic equations in generalized weighted Morrey spaces*, Acta Math. Sin. (Engl. Ser.) **32** (8), 911–924 (2016).
- [29] K.-P. HO, *Vector-valued maximal inequalities on weighted Orlicz-Morrey spaces*, Tokyo J. Math. **36** (2), 499–512 (2013).
- [30] H. JIA, D. LI, L. WANG, *Regularity in Orlicz spaces for the Poisson equation*, Manuscripta Math. **122**, 265–275 (2007).
- [31] F. JOHN, L. NIRENBERG, *On functions of bounded mean oscillation*, Comm. Pure Appl. Math. **14**, 415–426 (1961).
- [32] V. M. KOKILASHVILI, M. M. KRBEČ, *Weighted inequalities in Lorentz and Orlicz spaces*, World Scientific, Singapore (1991).
- [33] Y. KOMORI, S. SHIRAI, *Weighted Morrey spaces and a singular integral operator*, Math. Nachr. **282** (2), 219–231 (2009).
- [34] N. V. KRYLOV, *Parabolic and elliptic equations with VMO coefficients*, Comm. Partial. Differ. Equ. **32**, 453–475 (2007).
- [35] O. A. LADYZHENSKAYA, V. A. SOLONNIKOV, N. N. URAL'TSEVA, *Linear and Quasilinear Equations of Parabolic Type*, Transl. Math. Monographs **23**, Amer. Math. Soc., Providence, R.I. (1968).

- [36] Y. LIANG, E. NAKAI, D. YANG, J. ZHANG, *Boundedness of intrinsic Littlewood-Paley functions on Musielak-Orlicz Morrey and Campanato spaces*, Banach J. Math. Anal. **8** (1), 221–268 (2014).
- [37] A. MAUGERI, D. K. PLAGACHEV, L. G. SOFTOVA, *Elliptic and parabolic equations with discontinuous coefficients*, Wiley-VCH, Berlin (2000).
- [38] T. MIZUHARA, *Boundedness of some classical operators on generalized Morrey spaces*, Harmonic Anal., Proc. Conf., Sendai/Jap. 1990, ICM-90 Satell. Conf. Proc. 183–189 (1991).
- [39] C. B. MORREY, *On the solutions of quasi-linear elliptic partial differential equations*, Trans. Amer. Math. Soc. **43**, 126–166 (1938).
- [40] E. NAKAI, *Hardy-Littlewood maximal operator, singular integral operators and the Riesz potentials on generalized Morrey spaces*, Math. Nachr. **166**, 95–103 (1994).
- [41] M. N. OMAROVA, *Commutator of nonsingular integral on weighted Orlicz spaces*, Proc. Inst. Appl. Math. **10** (1), 76–86 (2021).
- [42] M. N. OMAROVA, *Nonsingular integral on weighted Orlicz spaces*, Trans. Natl. Acad. Sci. Azerb. Ser. Phys.-Tech. Math. Sci. **41** (1), Mathematics, 138–145 (2021).
- [43] M. N. OMAROVA, *Parabolic nonsingular integral operator and its commutators on weighted Orlicz spaces*, Azerb. J. Math. **13** (2), 1–13 (2023).
- [44] D. PLAGACHEV, L. SOFTOVA, *Fine regularity for elliptic systems with discontinuous ingredients*, J. Arch. Math. **86** (2), 145–153 (2006).
- [45] M. M. RAO, Z. D. REN, *Theory of Orlicz spaces*, M. Dekker, Inc., New York, (1991).
- [46] D. SARASON, *On functions of vanishes mean oscillation*, Trans. Amer. Math. Soc. **207**, 391–405 (1975).
- [47] Y. SAWANO, *A thought on generalized Morrey spaces*, Indonesian Math Soc. **25** (3), 210–281 (2019).
- [48] L. SOFTOVA, *Morrey-type regularity of solutions to parabolic problems with discontinuous data*, Manuscr. Math. **136** (3–4), 365–382 (2011).